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# LASER TELEMETER FOR AIR GUN APPLICATION

-Task Report-

by
L. M. Vallese
M. W. Wallace

JULY 1967

Picatinny Arsenal
Dover, New Jersey 07801

Contract DA 28-017-AMC-3455(A)
-Task 1-

ITT Federal Laboratories
Nutley, N.J. 07110





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SUMMARY

The work of design and fabrication of three Laser Telemeter Units having 18 channels of IRIG telemetry and using a PPM GaAs Laser is described. After a general discussion of the principles of telemetry and of the signal-to-noise enhancement properties of FM, PPM, and PCM systems, a detailed discussion of the electrical and of the mechanical design is presented.

## FOREWORD

The work of design and development of the Laser Telemeter for air gun was conducted under Task 1, Contract DA 28-017-AMC-3455(A), Picatinny Arsenal, Dover, New Jersey. The Contract Project Officer was Mr. Lawrence Ouellette. The personnel who conducted the work at ITT Federal Laboratories/Nutley, New Jersey consisted of Dr. L. M. Vallese, Mr. Milner W. Wallace, Mr. Richard Lachenauer.

The authors have considered it a privilege to work with Mr. Ouellette, who was the original creator of the concept of Laser Telemeter and who maintained cognizance of the effort throughout the program. Thanks are expressed to Mrs. J. Smith for her enthusiastic assistance in the secretarial work connected with this project.

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## 1. INTRODUCTION

In the following report, the work of design and fabrication of three 18-channel Laser Telemeter units for air-gun application developed under Contract DA 28-017-AMC-3455(A) - Task I - is presented. The design was initiated on November 29, 1966; the telemeter units were fabricated and were delivered to Picatinny Arsenal, New Jersey, on 1 May 1967.

The laser telemeter was first conceived at Picatinny Arsenal by Mr. Lawrence Ouellette, who also built an initial five-channel experimental model. Starting from this basic design, ITT Federal Laboratories developed an 18-channel model, fully operable in an air gun. The telemeter has been designated Type LT-18-357.

In the following, after a brief review of the basic techniques of telemetry and a comparison of the signal-to-noise ratios and data-transmission capacity of various modulation systems, a detailed description of the electrical and of the mechanical design is presented. Finally, a report on the successful performance of the Laser Telemeter in experiments conducted with an air gun at Frankford Arsenal is given.

## 2. THEORETICAL PRINCIPLES

### 2.1 Telemetry Techniques

The study of the variation with time of stresses, strains, temperatures, accelerations, etc., occurring during the operation of missiles and projectiles is extremely important for the design and development of the modern highly sophisticated weapons. Telemetry permits the realization of real-time monitoring; however, in the case of projectiles, the extremely high values of acceleration and temperature encountered, as well as the short times of flight, make the design of telemetry packages rather difficult.

In general, various telemetry techniques are available; these utilize frequency modulation of continuous carriers or modulation of pulse carriers (PAM, PPM, PDM, PCM) and combinations of the two methods.

The FM/FM technique utilizes a number of standard subcarrier oscillators (see Table 1) which are frequency-modulated with deviation ratio five by the data signals provided by the sensors. The over-all band of the various channels ranges from 400 c/s (Channel 1) to 70 Kc/s (Channel 18 or Channel E), and the selection and modulation of the various channels is made so as to avoid frequency overlapping. Thus, the channels may be added together (linear operation - designated "mixing") and constitute a frequency-multiplexing system, which can be demultiplexed readily by means of a suitable bank of filters. In the FM/FM technique, the multiplexed signal is utilized to frequency-modulate an RF carrier selected in the ranges 216 - 260 mc/s, or 1435 - 1535 mc/s, or 2200 - 2300 mc/s (Fig. 1).

A modification of the above technique is obtained by introduction of time-division multiplexing. As shown in Fig. 2, a number of the data channels may be connected at the inputs of a commutator, which samples each of them at a rate of $F$ times per sec and provides at its output a sequence of pulses which are utilized to frequency-modulate one of the subcarrier oscillators. It is well known that, in order that sampling may preserve the information carried in each channel, it is necessary that the sampling frequency be at least twice the highest frequency contained in the spectrum of the channel signal. The output of the commutator consists of a sequence of pulses from various channels which are interleaved and which possess a resultant PRF equal to the product of the number of channels sampled by the rate of sampling. Therefore, if $N$ channels are commutated, and if the maximum spectral frequency in any one channel is $f$, the sampling rate must be $F \geq 2f$ and the over-all prf at the commutator output is $NF \geq 2\,Nf$. The subcarrier oscillator which is to be frequency-modulated with the latter output signal must be selected so that its total frequency deviation is $10\,NF$ or larger.

The combination of time multiplexing with frequency multiplexing just described allows the utilization of the large data-frequency-response capability of the subcarrier oscillator (NF) to transmit a number of low data-rate channels (F) , and thus results in a greater economy of the design, although, of course, the over-all information capacity is not changed.

In the above-described technique, the data signals from the various channels frequency-modulate continuous subcarrier oscillators. Alternatively, the data signals may be made to modulate pulse carriers; for this purpose, the techniques of PAM (pulse-amplitude modulation), PDM (pulse-duration modulation), PPM (pulse-position modulation ), or PCM (pulse-code modulation) may be used. If a single data channel is present, and if its maximum spectral frequency is f , the output may be made to modulate directly a sequence of pulses, having prf equal 2f or larger. In the case of PCM, each pulse is modulated digitally, resulting in a group of shorter digits (bits) where the prf of the group of bits is 2f or larger. Finally, the modulated pulse sequence may be made to frequency- or phase-modulate the RF transmitter carrier. Thus, these techniques may be designated respectively PAM/FM, PDM/FM, PPM/FM, PCM/FM.

In general, more than one data channel is present; in order to utilize the above-described pulse-modulation techniques, a commutator is used, so that the outputs of the various data channels are time-multiplexed and appear as a resultant sequence of samples or pulses with prf NF (if N is the number of channels and F is the commutator rate). Clearly, in this case the basic prf of the carrier pulses to be modulated must be 2Nf or larger. An example of time-multiplexing of eight data channels in connection with a PAM technique is shown in Fig. 3; in this case, a master clock triggers a chain of flip-flops which, through a diode logic matrix, provide enabling pulses to the gates of the multiplexer. The multiplexed sampled data are further gated through a "duty cycle gate" which allows only the middle 50% of each sample, in order to remove transients and facilitate separation between channels and synchronization at the receiving end. For synchronization purposes, one portion of the transmitted "frame" is reserved for a sync pulse, which ensures the proper resetting of the demultiplexer binary divider chain; in addition, continuous control of the frequency and phase of the demultiplexer master clock is provided, so that the latter remains closely synchronized with the multiplexer master clock, even though frequency and phase shifts due to doppler effects or to other phenomena may occur.

A very important property of the multiplexer is its versatility in permitting an increase of the data-rate capability of a channel by <u>supercommutation</u> (by combining the inputs of two multiplexer gates together, obtaining the sum of the individual bandwidths); for example, in the case of Fig. 4, Channels 1 and 5, 2 and 6, 3 and 7 may be connected in parallel, because they divide the frame into equal time periods and thus result in samples taken at uniform intervals. For example, if the prf is 20 Kc, each channel of the eight channel multiplexers would have a sampling rate of 2500 c/s ; combining 1 and 5 in parallel gives a sampling rate of 5,000 c/s for the resulting data channel.

Another useful property is the ability to apportion a given bandwidth among a number of channels by <u>subcommutation</u>. For example, in the case of Fig. 4, if one of the multiplexer inputs at 2500-c sampling rate is connected to the output of another multiplexer, having (say) 16 channels, each of the input channels of the latter would have a sampling rate of about 156 c/s .

### 2.2 Signal-to-Noise Ratio of Various Modulation Techniques

Study of the values of the signal-to-noise ratio after detection ($S_o/N_o$) for various modulation techniques shows that, in certain cases, this ratio may be made larger than the corresponding signal-to-noise ratio before detection ($S_c/N_c$) . For example, neglecting the noise contributions within the receiver, it is found that, for FM systems, the following relations exist:

$$\left(\frac{S_o}{N_o}\right)_{FM} = 3\,\beta^2 \left(\frac{S_c}{N_c}\right)$$

where $\beta = \Delta\omega/\omega_m$ is the modulation index; the latter relation is valid provided $S_c/N_c$ is above a threshold value which, for large $B$, is generally taken as 20:1 (i.e., 13 db). In amplitude-modulated systems, the signal-to-noise ratio after detection cannot be increased above the value $S_c/N_c$. This property of FM systems permits the efficient exchange of bandwidth for power; for example, if $\beta = 5$, the FM output S/N is 75 times that of an equivalent AM system. Alternatively, for the same S/N at the output of both FM and AM detectors, the required power of the FM carrier is 1/75 that of the AM carrier.

Consider now the technique of pulse-position modulation. In this case, one finds the following relationship:

$$\frac{S_o}{N_o} = 2\, t_o^{\,2}\, \beta^2\, \frac{S_c}{N_c}$$

where $t_o$ is the maximum modulation displacement in any one direction away from the unmodulated position of the pulse, and $\beta$ is the system bandwidth. Thus, for a given value of the bandwidth, the signal-to-noise ratio may be enhanced provided a suitable maximum modulation displacement is realized. Vice versa, for a given modulation displacement, the enhancement is obtained by increasing the system bandwidth. As an example, if $t_o = 1\mu sec$ and $B = 3.3$ mc/s, one has:

$$\frac{S_o}{N_o} = 22\,\frac{S_c}{N_c}$$

an improvement of 13 db.

In the case of PCM systems, the signal-to-noise ratio varies exponentially with the bandwidth. In fact, assume that the PCM is a binary (i.e., that it transmits two amplitudes only, such as 1, 0 or 1, -1); if there are $m$ bits per group, the total number of quantized levels is $s = 2^m$. In addition, if the sampling rate is $2f$, the number of bits per level is $m$, the number of pulses transmitted is $2mf$, and the channel bandwidth is $\beta = mf$.

At the receiver end, the pulses are reshaped, removing noise and distortion added in transmission. When the signal-to-noise ratio is above a threshold on the order of 20 db, the probability of error at detection becomes very small (Fig. 5). The information capacity of the PCM system for double-polarity digit pulses is written as follows:

$$C = m f \log_2 \left(1 + \frac{2 S_{ave}}{k^2 N}\right)$$

where $S_{ave}$ is the average signal power and $k$ is the ratio between voltage quantization step and rms noise voltage $N$. In an ideal communication system of bandwidth $mf$, one has:

$$C = m f \log_2 \left(1 + \frac{S_{ave}}{N}\right) ;$$

thus, it is noted that the capacity of PCM systems is closely related to the maximum ideal value and that it is proportional to the bandwidth; furthermore, power and bandwidth are exchanged on a logarithmic basis. For a given bandwidth, the theoretical value of the capacity is obtained using a power $k^2/12$ times larger than the theoretical value; at threshold, this is about 8 times. Finally, the ratio $S_o/N_o$ at the decoder output varies linearly with $m$; i.e.,

$$\left(\frac{S_o}{N_o}\right)_{db} = 10.8 + 6\,m$$

Recapitulating, PCM offers a greater improvement of S/N than other modulation systems. In addition, because of the possibility of regenerating the individual bit pulses, the S/N ratio is not affected by fluctuation noise in transmission, provided the S/N is above threshold.

In the ITTFL design of the Laser Telemeter, a PPM technique was utilized, as explained later; the maximum modulation displacement was on the order of $1\mu sec$ or higher. The system bandwidth, which includes the bandwidth of the receiver, has not been determined.

## 2.3 Data-Transmission Capacity

Theoretically, the information capacity of a channel (i.e., the maximum rate of transmitting information) is proportional to the system bandwidth and depends upon the number of different symbols to be transmitted and upon their probability of occurrence; for example, in an ideal communication system,

$$C = \beta \log_2 \left(1 + \frac{S_{ave}}{N}\right)$$

Consider a telemetry channel of given bandwidth. If the modulation technique is FM (i.e., if the data signals are made to modulate a continuous subcarrier oscillator), the ratio between the maximum frequency deviation of the subcarrier oscillator and the corresponding modulation frequency is the modulation index $\beta = \Delta\omega/\omega_m$ . For IRIG standards, this ratio is taken as 5 , in order that wideband FM be obtained. In general, the critical value $\beta = \pi/2$ is taken as representing the transition between narrowband FM (spectral energy concentrated at the carrier) and wideband FM (spectral energy spread over a wide frequency range).

Thus, the data capacity of the various FM IRIG channels is given approximately by $\Delta_D/5$ . It has values of 110 c/s for Channel 11 ; 450 c/s for Channel 15 ; 1050 c/s for Channel 18 ; 2100 c/s for Channel E ; etc.

The data rates expected in the case of projectiles are in general within these ranges. The motion of the projectile within the gun is analyzed by the science of "interior ballistics". In general, a force, expressed as the product of the pressure times the cross-section of the projectile or gun barrel, is applied abruptly at the start and imparts an acceleration depending upon the mass of the projectile; as an example:

$$x'' = F/m = a$$

Assuming that the motion is only translational, and neglecting friction and resistance of air, one finds that, during a time interval $0, \tau$, the projectile receives increments in velocity and position given by:

$$\Delta v = \frac{F_{ave}\ \tau}{m}$$

$$\Delta x = \frac{1}{2}\ \frac{F_{ave}\ \tau^2}{m}$$

where $F_{ave}$ is the mean value of the force in the $0, \tau$ time interval . In the case of the air gun, the phenomena are complicated by the effect of air resistance as the projectile nears the end of the path.

Flight times for air-gun lengths on the order of 50 to 100 ft are on the order of 10 - 20 msec , depending upon the mass of the projectile.

In order to evaluate the corresponding data bandwidth, assume that the sensor output waveform possesses a rectangular shape, with duration $\tau$ and amplitude V (Fig. 6). The Fourier transform of this signal is (Fig. 7):

$$F(j\omega) = V\tau \frac{\sin(\omega\tau/2)}{(\omega\tau/2)}$$

The corresponding bandwidth may be taken as $\Delta f = 1/\tau$ ; this value represents an approximation, but is acceptable since the bandwidth is not critically dependent upon the waveform of the sensor output. In fact, if one assumes that the latter waveform has a triangular shape, the Fourier transform is expressed as follows:

$$F(j\omega) = V\tau \left[ \frac{\sin(\omega\tau/2)}{\omega\tau/2} \right]^2$$

and the effective bandwidth is still approximately $\Delta f = 1/\tau$.

Thus, it is seen that, using FM telemetry Channel 18, with frequency response 1050 c/s , a data rate corresponding to a flight time as short as 1 millisecond may be transmitted usefully. In practice, it is expected that the applicable data rates are much smaller than the above value.

## 3. ELECTRICAL DESIGN OF THE LASER TELEMETER

The selection of the optimum modulation technique for the design of a laser telemeter is made on the basis of considerations of modulation properties of the laser. A laser telemeter differs basically from an RF telemeter because its output carrier is emitted as a highly collimated beam, instead of as an isotropic radiation pattern; thus, the use of a laser requires radically different system design. The high directionality of the emitted carrier is useful in the case of projectiles and missiles to provide trajectory and velocity information. In the case of application to the air gun, the trajectory is a straight line contained in a dark cylinder, at the end of which the antenna of the receiver is located. Thus, the laser carrier lends itself very conveniently to this particular application and provides a highly intense radiation field and a large signal-to-noise ratio because of its beam-collimation properties.

The GaAs laser is best suited for the design of the telemeter because it operates with high efficiency and requires unsophisticated modulators. However, the power-dissipation properties must be taken into account in determining the actual capabilities of the design. The laser diode is generally built on a small support of molybdenum, whose length (2-3 mils) keeps the junction away from the basic thermal sink and thus results in a limitation of the cooling and an increase of the junction temperature under high current drive.

In general, if it is assumed that the junction temperature is maintained constant at an equilibrium value, there exists a threshold of input current (and of input power) in correspondence of which laser action occurs. As an example, at room temperature, the laser diode RCA TA2628 has a typical current threshold of $\sim$ 10A--i.e., an input power threshold of $\sim$ 15 watts (taking into account the input resistance of $\sim$.15 ohm. As the junction temperature $T$ is decreased, the threshold current varies with the power $T^3$. Assuming that the laser is driven with pulses of peak power $P_p$, of duration $\tau$, and of repetition frequency $f$, the average power input is calculated as follows:

$$P_{ave} = P_p \tau f$$

For a given thermal dissipation design, the values of $P_{ave}$ and of $P_p$ are prescribed; on the other hand, the frequency $f$ must be selected in accordance with the sampling theorem (i.e., about twice the maximum frequency of the spectral distribution of the data signals). There remains the parameter $\tau$ which must be made as small as possible, consistent with the response characteristics of the laser diode. In practice, pulses as narrow as 5 nanoseconds have been used for the laser telemeter design; the frequency f has been selected as 150 Kc/s and thus the ratio $P_{ave}/P_p$ has been made approximately $750 \times 10^{-6}$.

A further decrease of the power dissipation of the laser telemeter has been realized by operating the unit intermittently--i.e., with pulse trains of duration T' and repetition frequency f'. In practical realization, the values of T' and of f' have been selected as ~45 msecs and ~0.5 c/sec respectively. The reduced power dissipation has been found helpful in improving the operation of the laser as well as that of the avalanche driver stages, and has permitted the utilization of a smaller-size dc-dc converter; on the other hand, the intermittent mode of operation of the laser does not interfere with its utilization since the flight time in the air gun is expected to be on the order of 10 - 20 milliseconds.

A block diagram of the design of the laser telemeter is shown in Fig. 8. The laser utilizes an FM/PPM-modulation technique; eighteen separate input data channels are available and are used to frequency-modulate a corresponding number of standard IRIG subcarrier oscillators Channels 1 to 18. The outputs of the latter are added together ("mixed") with application of preemphasis and are finally added linearly to a 150-Kc sinusoidal carrier, generated by a local oscillator. The resulting voltage is converted into a pulse sequence with positive-going pulses occurring in correspondence of the zero crossings of the wave; this is obtained by means of amplification, limiting, differentiation, clipping. The sequence carries information by a pulse-position-modulation technique. Finally, the pulses are utilized to trigger avalanche stages, which in turn drive the GaAs laser.

The intermittent pulse-train operation is obtained by recourse to a gating transistor, controlled by a signal generated in a dissymmetric multivibrator (the wave form is a rectangular pulse with duration ~ 45 msec, rep rate ~ 0.5/sec). The avalanche stages utilize 2N3507 transistors; these have been selected after careful examination of a number of units. As an example, in Table 2 there are summarized the experimental data obtained comparing the amplitudes of the output pulses, the corresponding time durations, the minimum collector avalanche voltages, the maximum permissible collector voltages for a number of transistors--Type 2N3034, 2N3035, and 2N3507. The avalanche stages are supplied from a dc-dc converter; however, since the current drain of the avalanche transistors is very high during the ON state, two large storage capacitors (50μF) have been added to supply additional power at the peak of the demand.

A detailed circuit diagram of the laser telemeter is shown in Fig. 9; among the details of design of interest we note the use of a clamping diode at the base of first transistor 2N3507, to raise the trigger pulse above ground; the use of diode FD100 to provide a return path for the charging current of the capacitors in the avalanche stages; the use of a voltage divider to provide stable and accurate supply voltages for the drive and final avalanche stages; the use of two parallel-connected output avalanche stages. Waveforms of the signals appearing at various points of the system have been taken and are shown in Figs. 10 to 14. In Fig. 10 is shown the output pulse obtained by replacing the laser diode with a 0.9-ohm resistor; the visual observation was made using Tektronix Scopes Mod 545A and Mod 585, which have respectively 15-nsec and 4.5-nsec rise time; the measurement of the pulse duration is ~15 nsec with Mod 545A and ~ 5nsec with Mod 585; the peak current is ~7.5A .

The shape of the output pulse train is shown also in Fig. 10. In this case, the pulse-train duration was 42 milliseconds; the train rep rate was 0.45/sec ; the pulse rep rate was 150 Kc/s ; the peak current was initially 7.5A and dropped to 5A at the pulse end.

In Fig. 11, the waveform of the pulses driving the final avalanche stages is shown. It is seen that the peak voltage varies from 6V at the beginning of the pulse train to 5V at the end of the train; thus, a smaller droop than that shown at the final stage is present.

In Fig. 12, the waveshape of the pulses driving the first avalanche stage is shown in the case of no modulation; these pulses have a peak of 4V and a duration of about 6.2 μsec. When telemetry signals are applied, a periodic back-and-forth shift ("jitter") of the said pulses about their "no-modulation" position occurs.

In Fig. 13, the waveshape of the signals consisting of the 150 Kc/s carrier with and without superimposed telemetry signals is shown.

In Fig. 14, the envelope of the pulse train (gate pulse) is presented; this has a magnitude of 8 - 10V, a duration of 42 msec, and a rep rate of 1 per 2.2 sec.

## 4. MECHANICAL DESIGN OF THE LASER TELEMETER

A general view of the Laser Telemetry Unit is shown in Fig. 15. The over-all weight is 7 lbs. Since it is comprised of several more-or-less discrete elements or subassemblies, a brief description of each can be given.

Recessed in the base plate is a Winchester Connector, to which all external connections may be made for both operation of the Telemeter and recharging of the batteries. Internal connections to this unit terminal are listed in Fig. 16. The mating external connector must provide jumper connections as shown in Fig. 17 for operation of the unit or as shown in Fig. 18 for recharging the batteries.

To the inside of this base plate is screwed the special mount containing the 18 subcarrier oscillators plus a mixer-amplifier. This mount also has a similar terminal to that of the entire unit so that it plugs into the prewired socket when the base plate is screwed to the rather intricate aluminum block that carries the DC-DC converter. No attempt has been made to show the many wires that exist in the junction box which can be located on the drawing by its cover, Item 7.0. These wires, the back of the terminals to which they are connected, and the DC-DC converter all are encapsulated with High Temp Resin or Dow-Corning Silastic.

The next assembly is the Battery Block of aluminum in which are potted the batteries, their interconnections, and a socket through which the mixed signal and DC voltages are connected to the two layers of encapsulated circuits indicated as Item 5.

The circuits contained in the first layer are the carrier oscillator and the multivibrator which gates the unit on periodically. The second layer contains the remainder of the circuit stages. Each of these layers uses cordwood construction between 1/32-in.-thick fiberglass disks. Many connections were made by soldering as sound resistances welds were not obtained on the leads of many of the available components. All of these soldered connections were made mechanically by binding and crimping the leads so that the circuits were complete before soldering. Each layer contains four brass bushings, with those of lower layer threaded to receive No. 6-32 screws. This system makes the two layers into a single unit with the screws and bushings providing more dimensional stability than the potting resin alone can achieve. The six interconnections between layers are clinched and soldered near the outer diameter of the interface and are covered with Silastic.

To provide the very short pulses (about 5-nanosecond duration), the final avalanche transistor stage is located centrally just beneath the transistor socket into which the GaAs laser is plugged. Plugging-in rather than solidly wiring-in the laser was chosen to facilitate replacement of the latter. However, if solid wiring connection is used, it may be possible to decrease further the duration of the laser pulses, thus improving the over-all thermal performance.

The laser used is the type RCA-TA2628. Though this laser can be operated at room temperature, the current required is 10 - 15 Amperes, and the laser still must be cooled to maintain it at room temperature.

During the course of work on this contract, it has been found that these lasers can be operated with 5-nsec pulses at 150,000 pulses per second at any temperature below -30°C when the driving circuit has only one of the two transistors operating. The second avalanche transistor doubles the current to assure above-threshold lasing. It was also found that, cooling with dry ice in the annular channel of Item 4.00, about 30 minutes of operation could be obtained. Since this time interval coincides with the permissible discharge time of the batteries, it is considered adequate.

Cooling of the laser is obtained by clamping it in a brass collar with an annular channel in which a doughnut of dry ice is placed. Since the case of the laser is above ground, the collar is mounted on a 3/16-in.-thick disk of fiber glass. Thus, the laser is held in the collar with a brass jam nut, and its 1/2-in.-long leads (one insulated with teflon sleeving) pass through individual holes in the bottom of the collar, then through a common clearance hole in the fiberglass and into the transistor socket in the circuit deck.

The battery block, DC-DC converter block, and the subcarrier oscillator base plate all are mounted together with stainless-steel screws; on the other hand, the circuit deck assembly and laser head are plugged in, and must be held with an outer stainless-steel case, Item 3.00, and the nose piece, Item 1.00. Because of the usual slight out-of-round of stainless-steel tubing and slight misalignment of the several assemblies within the unit, the case is a very snug fit. Three set screws, Item 2.00, are used to hold the nose piece to the case. This arrangement holds the unit together only adequately for handling; but when it is loaded into the vehicle of an air gun and a jam nut run down against the shoulder of the nose piece, everything is made secure.

Collimation of the laser beam is obtained by means of a lens supported in a brass holder and secured with a stainless-steel jam nut in the aluminum nose piece. Finally, photographs of the completed Laser Telemeter Unit are shown in Figs. 19 and 20.

## 5. CONCLUSIONS

The work of design and fabrication of the Laser Telemeter Unit was completed successfully. The performance of the laser diode exceeded the original hopes, and the circuits of pulse generation, avalanche, modulation, etc., were also brought to a high degree of refinement. A judicious compromise between thermal and electrical design was achieved.

Preliminary tests conducted at Frankford Arsenal in a 70-ft air gun have shown that the Laser Units withstand very well the accelerations and the stresses produced in this type of experimentation. No damage to any components, including the laser diode, was noted. Information data placed on Channel 17, 52.5 Kc/s and consisting of a 100-c/s sinewave, was recovered from the tape recording made during the test.

It is expected that further advances of design will be possible on the basis of the results obtained with the present Telemeter. In particular, the duration of the pulses and their duty cycle may be increased, thus extending the range of applicability of the device. Additional improvements in weight may be obtained by more-extensive recourse to integrated circuits.

## TABLE I

### SUBCARRIER OSCILLATOR FREQUENCIES

| BAND | CENTER FREQ. (cps) | LOWER LIMIT (cps) | UPPER LIMIT (cps) | DEVIATION (%) | FREQUENCY RESPONSE (cps) |
|---|---|---|---|---|---|
| 1 | 400 | 370 | 430 | ±7.5 | 6 |
| 2 | 560 | 518 | 602 | " | 8.4 |
| 3 | 730 | 675 | 785 | " | 11 |
| 4 | 960 | 888 | 1,032 | " | 14 |
| 5 | 1,300 | 1,202 | 1,398 | " | 20 |
| 6 | 1,700 | 1,572 | 1,828 | " | 25 |
| 7 | 2,300 | 2,127 | 2,473 | " | 35 |
| 8 | 3,000 | 2,775 | 3,225 | " | 45 |
| 9 | 3,900 | 3,607 | 4,193 | " | 59 |
| 10 | 5,400 | 4,995 | 5,805 | " | 81 |
| 11 | 7,350 | 6,799 | 7,901 | " | 110 |
| 12 | 10,500 | 9,712 | 11,288 | " | 160 |
| 13 | 14,500 | 13,412 | 15,588 | " | 220 |
| 14 | 22,000 | 20,350 | 23,650 | " | 330 |
| 15 | 30,000 | 27,750 | 32,250 | " | 450 |
| 16 | 40,000 | 37,000 | 43,000 | " | 600 |
| 17 | 52,500 | 48,560 | 56,440 | " | 790 |
| 18 | 70,000 | 64,750 | 75,250 | " | 1,050 |
| A | 22,000 | 18,700 | 25,300 | ±15 | 660 |
| B | 30,000 | 25,500 | 34,500 | " | 900 |
| C | 40,000 | 34,000 | 46,000 | " | 1,200 |
| D | 52,500 | 44,620 | 60,380 | " | 1,600 |
| E | 70,000 | 59,500 | 80,500 | " | 2,100 |

T A B L E  II

TESTS OF AVALANCHE TRANSISTORS

| TRANSISTOR TYPE | NO. | SIGNAL INPUT | | SIGNAL OUTPUT | | MIN. AVALANCHE VOLTAGE | | SELF-AVALANCHE VOLTAGE |
|---|---|---|---|---|---|---|---|---|
| 3507 | 2 | 6 V | 20NS | 20V | 14NS | 120V | Not Aval. | 130V |
| 3034 | A | 1.2V | 20NS | >20V | 5NS | 85V | " | 90V |
| 3507 | 31 | 1.3V | 20NS | >20V | 5NS | 95V | " | 155V |
| 3507 | 1 | 4 V | 20NS | 18V | 10NS | 100V | " | 110V |
| 3034 | B | 1.3V | 20NS | >20V | 5NS | 87V | | 92V |
| 3507 | 5 | 4 V | 20NS | 15V | 15NS | 95V | Not Aval. | 100V |
| 3507 | 9 | 4 V | 20NS | 17V | 13NS | 100V | " | 105V |
| 3507 | 7 | 4 V | 20NS | 18V | 12NS | 100V | " | 110V |
| 3507 | 8 | 4 V | 20NS | 20V | 12NS | 105V | " | 120V |
| 3507 | 4 | 4 V | 20NS | 17V | 15NS | 120V | " | 140V |
| 3507 | 6 | 4 V | 20NS | 19V | 12NS | 115V | " | 125V |
| 3507 | 3 | 4 V | 20NS | 19V | 14NS | 120V | " | 130V |
| 3034 | C | 1.4V | 20NS | 17V | 5NS | 70V | | 75V |
| 3034 | D | 1.3V | 20NS | >20V | 5NS | 80V | | 90V |
| 3034 | E | 1.3V | 20NS | >20V | 5NS | 80V | | 92V |
| 3034 | F | 1.2V | 20NS | >20V | 5NS | 82V | | 92V |
| 3034 | G | 1.2V | 20NS | >20V | 5NS | 85V | | 90V |
| 3034 | H | 1.2V | 20NS | 20V | 5NS | 76V | | 94V |
| 3034 | I | 1.2V | 20NS | 18V | 5NS | 70V | | 85V |
| 3035 | 1 | 1.2V | 20NS | 14V | 5NS | 65V | | 67V |
| 3035 | 2 | 1.2V | 20NS | 10V | 7NS | 70V | | 72V |
| 3035 | 3 | 1.2V | 20NS | 15V | 5NS | 60V | | 78V |
| 3035 | 4 | 1.4V | 20NS | 9V | 8NS | 60V | | 60V |
| 3035 | 5 | 1.2V | 20NS | 11V | 5NS | 55V | | 57V |
| 3035 | 6 | 1.3V | 20NS | >20V | 5NS | 80V | Very Unstable | 60V |
| 3035 | 7 | 1.2V | 20NS | 14V | 5NS | 58V | | 78V |
| 3035 | 8 | 1.1V | 20NS | 13V | 5NS | 65V | | 68V |
| 3035 | 9 | | Doesn't Avalanche | | | | | 40V |
| 3035 | 10 | 1.2V | 20NS | 9V | 10NS | 70V | | 70V |
| 3507 | 1 | 1.3V | 20NS | >20V | 5NS | 95V | | 143V |
| 3507 | 2 | 1.4V | 20NS | >20V | 5NS | 100V | | 160V |
| 3507 | 3 | 1.2V | 20NS | 16V | 5NS | 95V | Very Unstable | 75V |
| 3507 | 4 | 1.4V | 20NS | >20V | 5NS | 100V | | 150V |
| 3507 | 5 | 1.4V | 20NS | >20V | 5NS | 105V | | 130V |
| 3507 | 6 | 1.4V | 20NS | >20V | 5NS | 105V | | 160V |
| 3507 | 8 | 1.3V | 20NS | >20V | 5NS | 95V | | 105V |
| 3507 | 9 | | Doesn't Avalanche at all | | | | | 80V |
| 3507 | 10 | 1.4V | 20NS | >20V | 5NS | 105V | | 155V |
| 3507 | 11 | 1.4V | 20NS | >20V | 5NS | 105V | | 145V |
| 3507 | 12 | 1.2V | 20NS | >20V | 5NS | 100V | | 100V |
| 3507 | 13 | 1.3V | 20NS | >20V | 5NS | 115V | | 170V |
| 3507 | 14 | 1.4V | 20NS | >20V | 5NS | 105V | | 160V |
| 3507 | 15 | 1.4V | 20NS | >20V | 5NS | 95V | | 145V |

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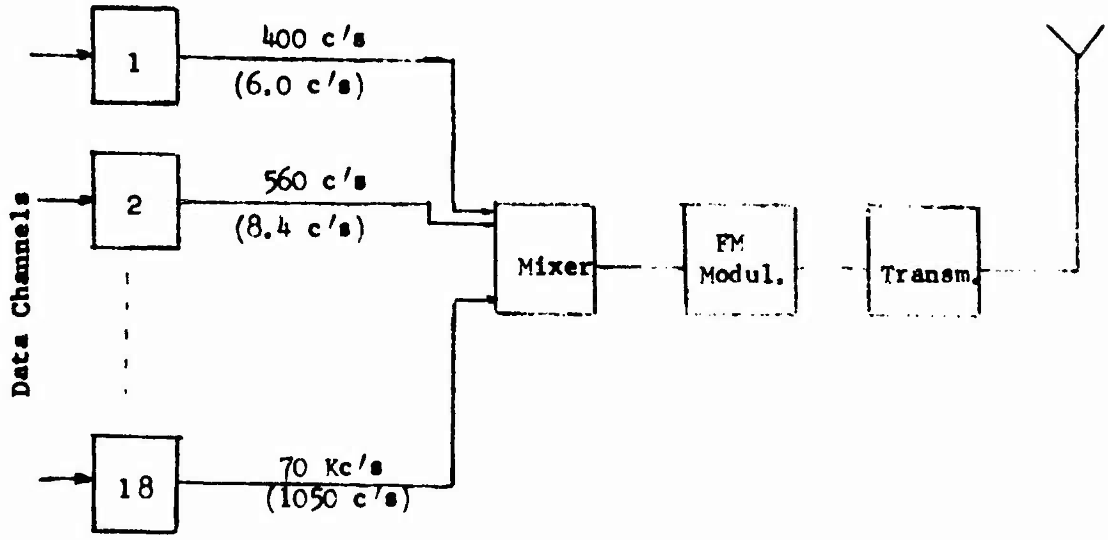



FIG. 1 - FREQUENCY MULTIPLEXING IN FM/FM TELEMETRY

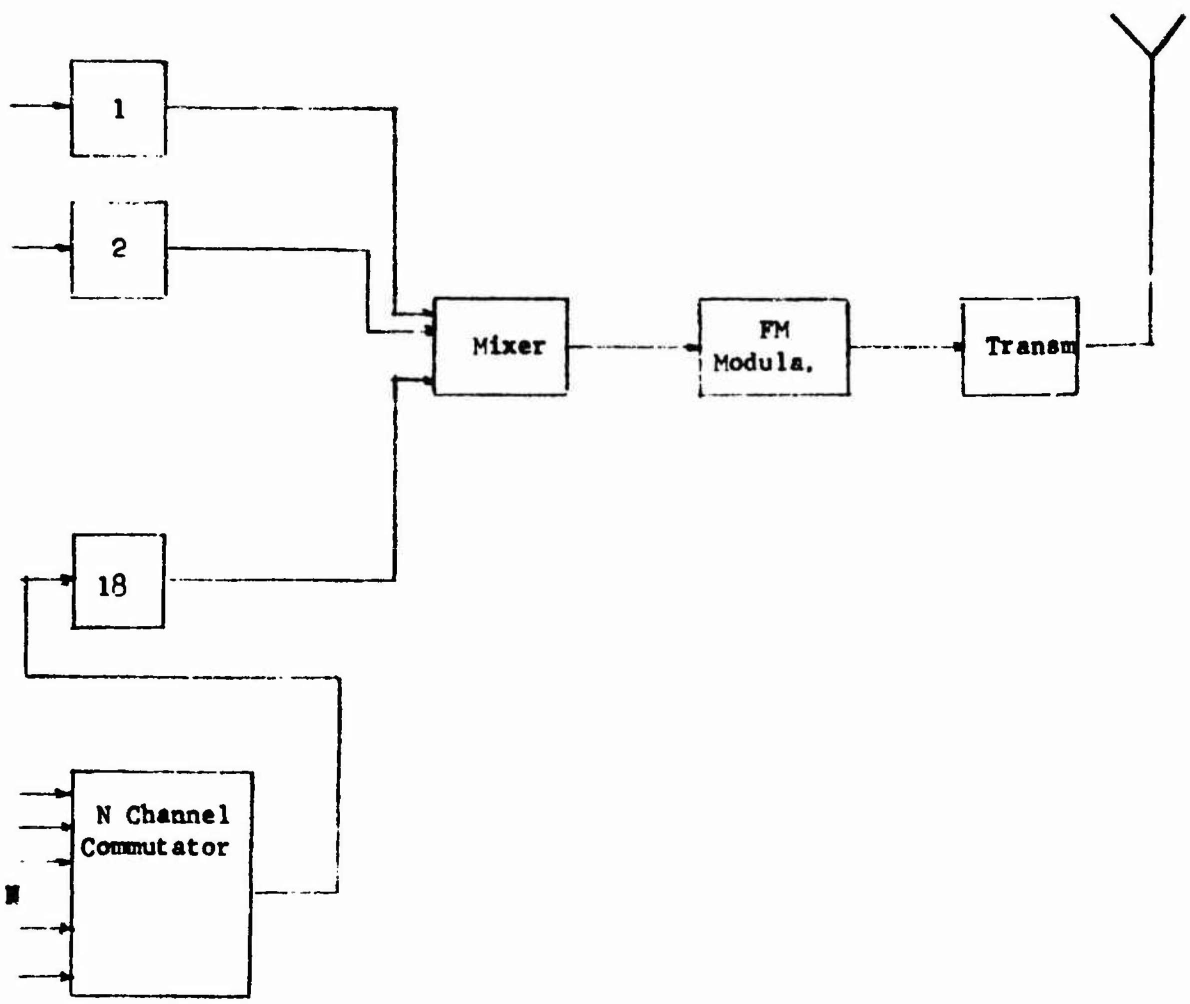



FIG. 2 - TIME-DIVISION MULTIPLEXING IN FM/FM TELEMETRY

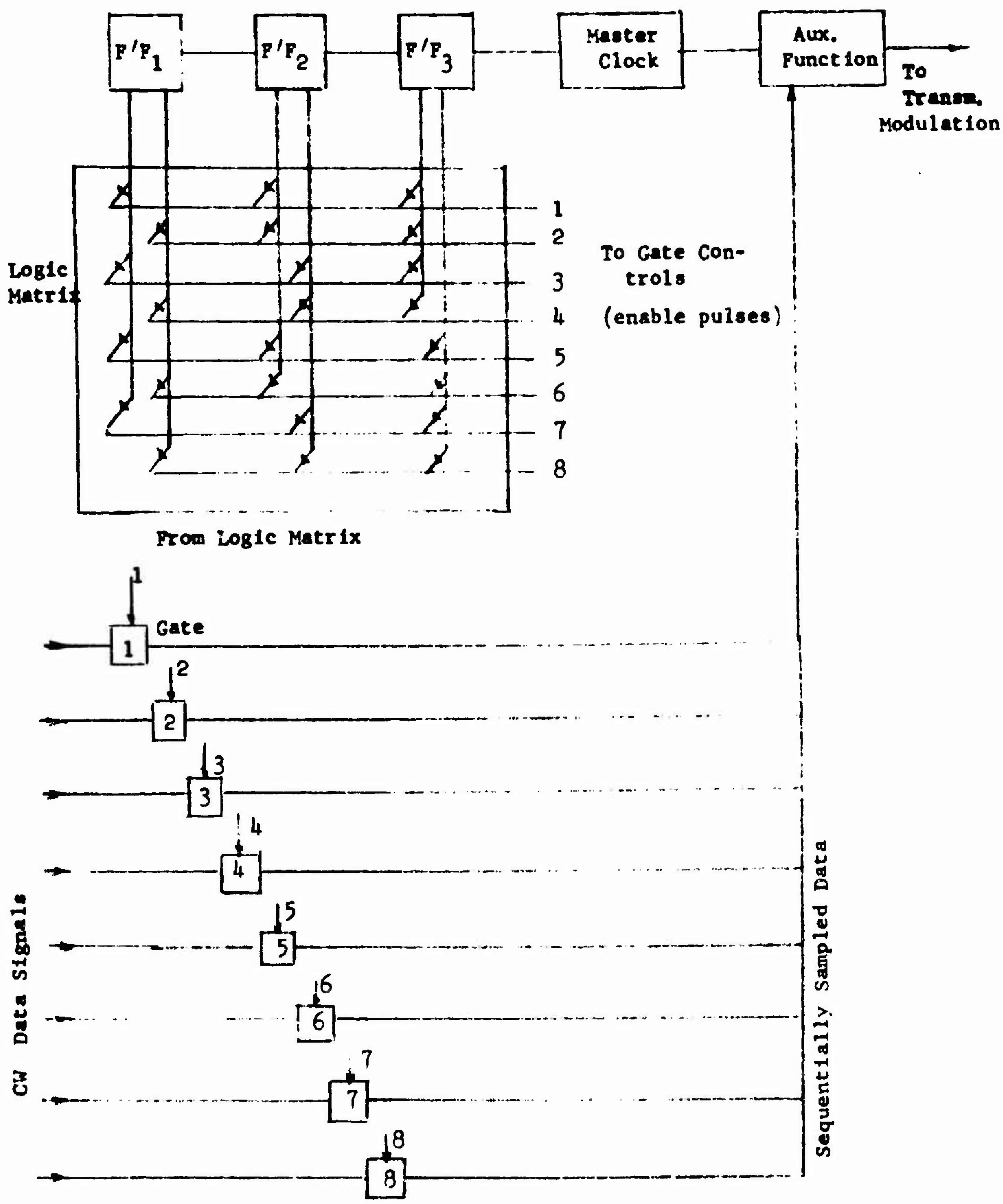



FIG. 3 - EXAMPLE OF 8-CHANNEL MULTIPLEXER

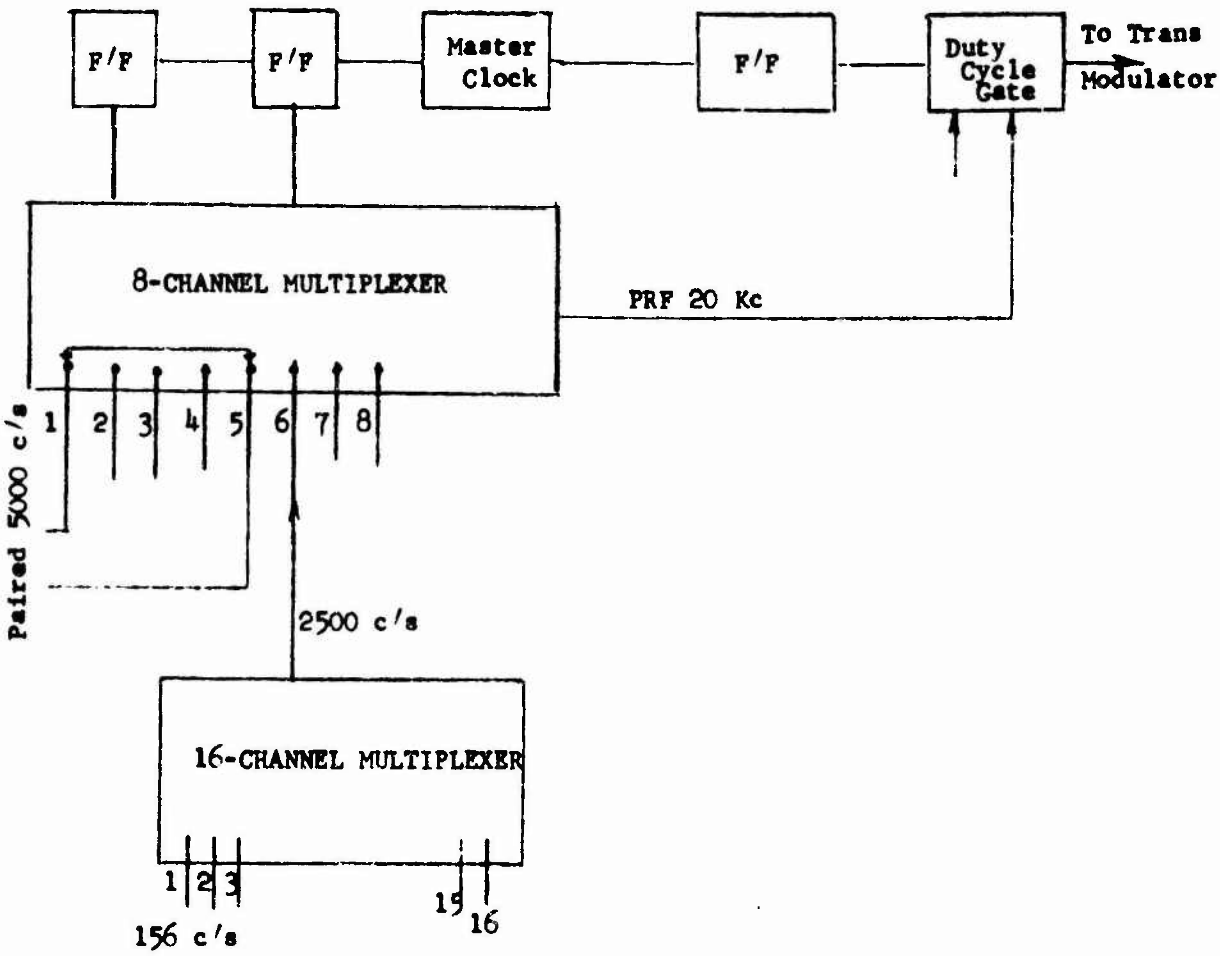



FIG. 4 - EXAMPLE OF SUPERCOMMUTATION AND OF SUBCOMMUTATION

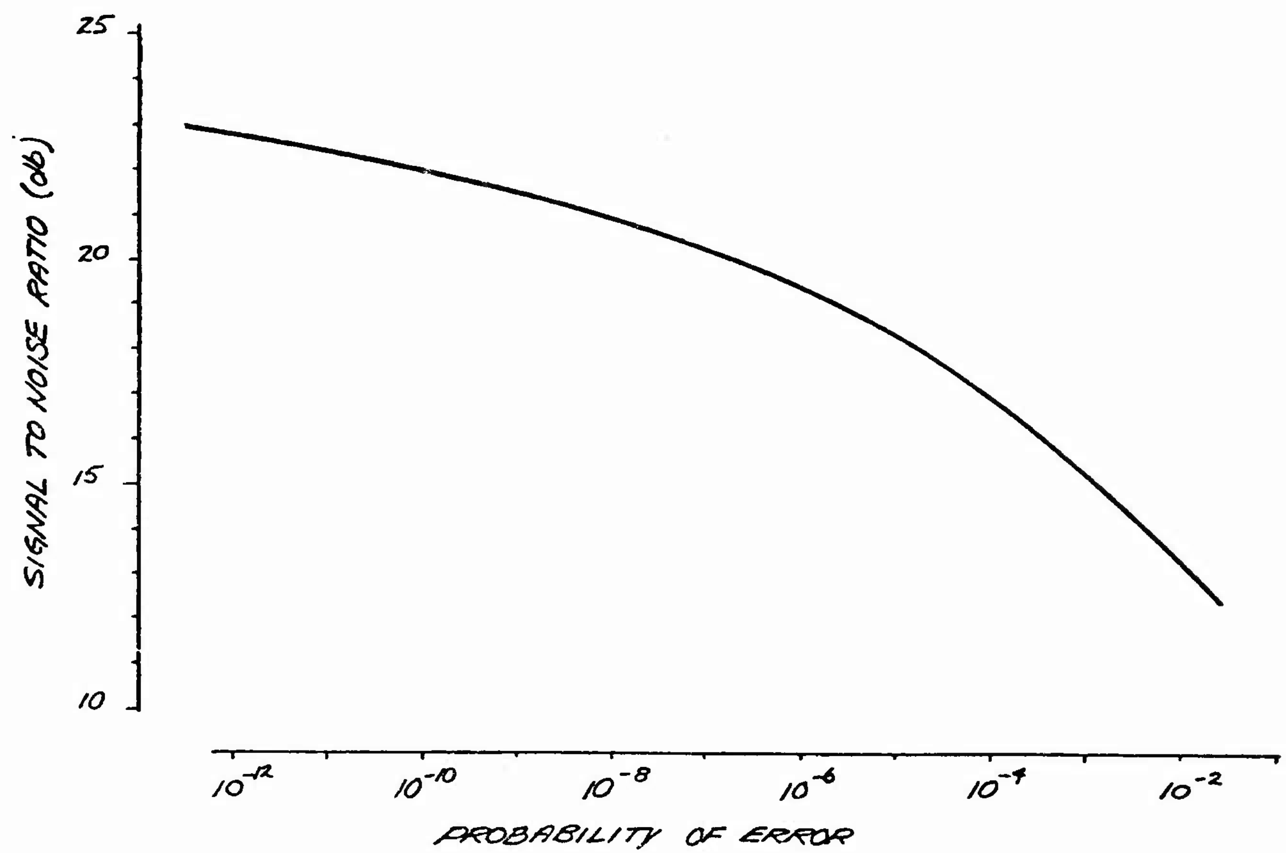



Fig. 5 - Theoretical Error Rate for Binary System

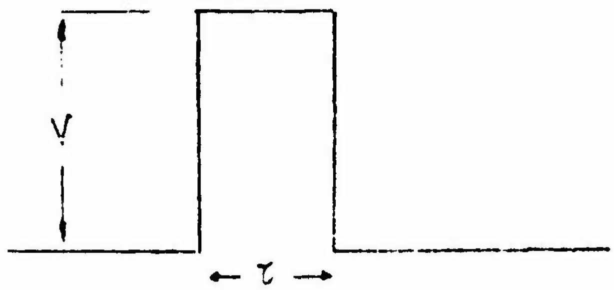



FIG. 6 - IDEALIZED WAVEFORM OF SENSOR OUTPUT SIGNALS

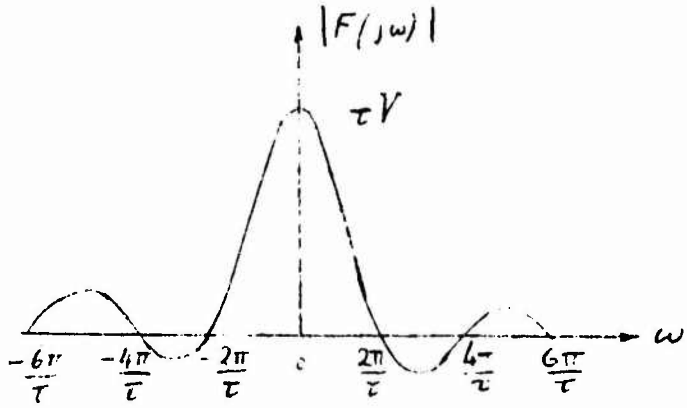



FIG. 7 - FOURIER SPECTRUM OF RECTANGULAR WAVEFORM OF FIG. 6

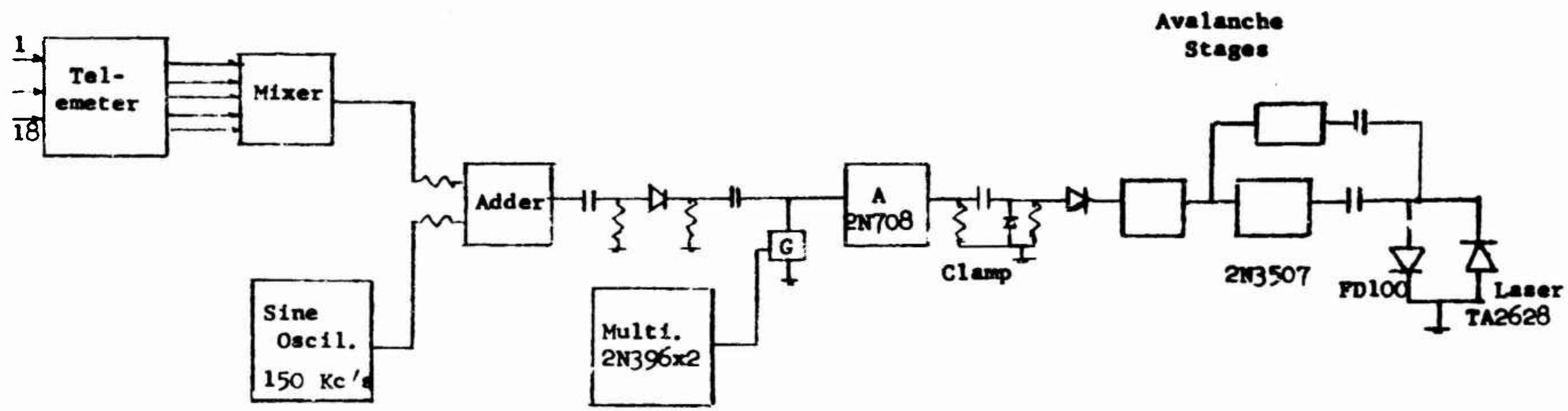
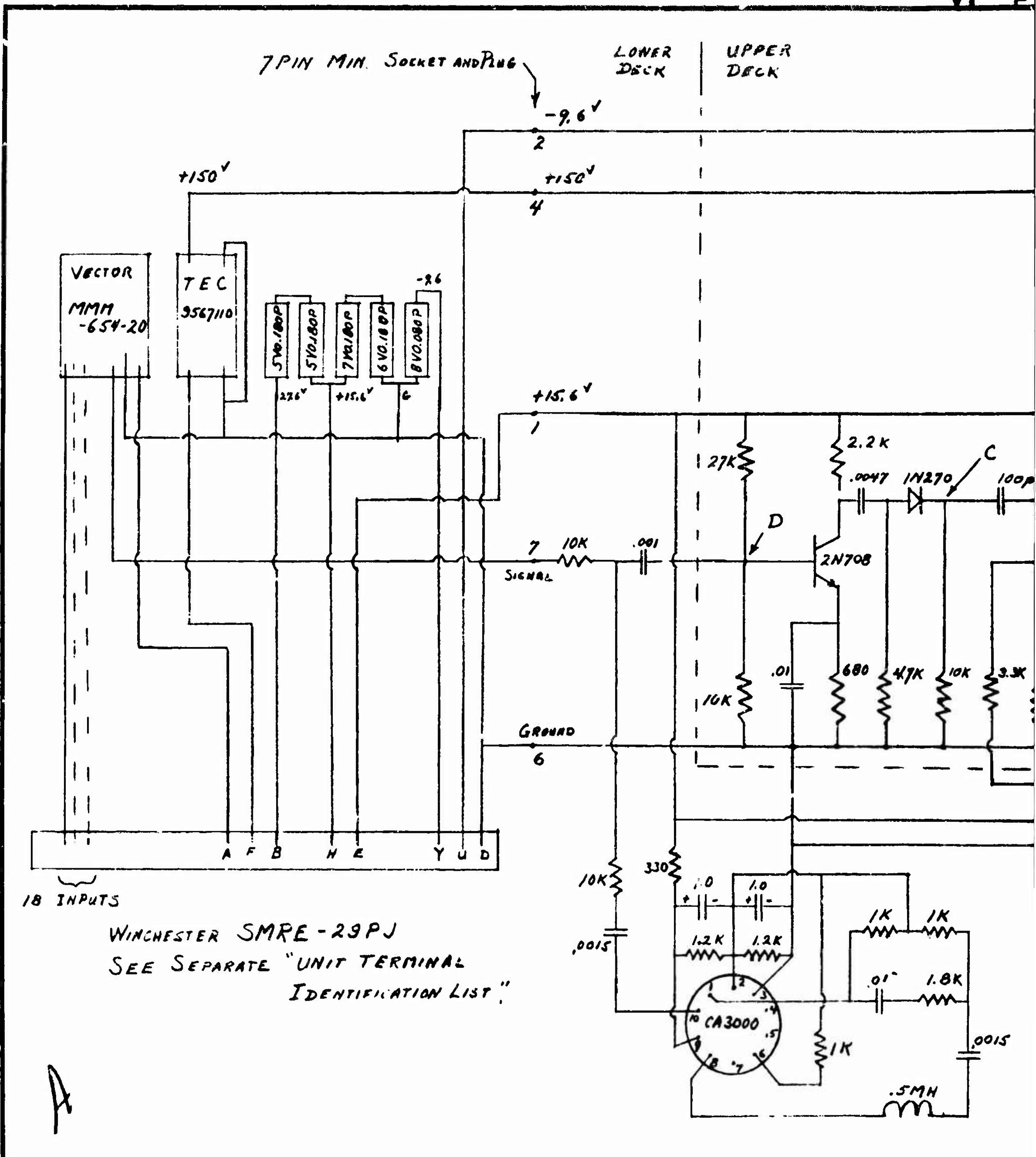



FIG. 8 - BLOCK DIAGRAM OF LASER TELEMETER CIRCUIT

ITTFL D211(N)-V REV. 6-64






| | |
|---|---|
| DRAWN BY M. H. Wallace | DATE 5-1-67 |
| CHECKED BY R. H. Lawrence | DATE 5-1-67 |
| APPROVED BY R. h. Valle | DATE 5-1-67 |

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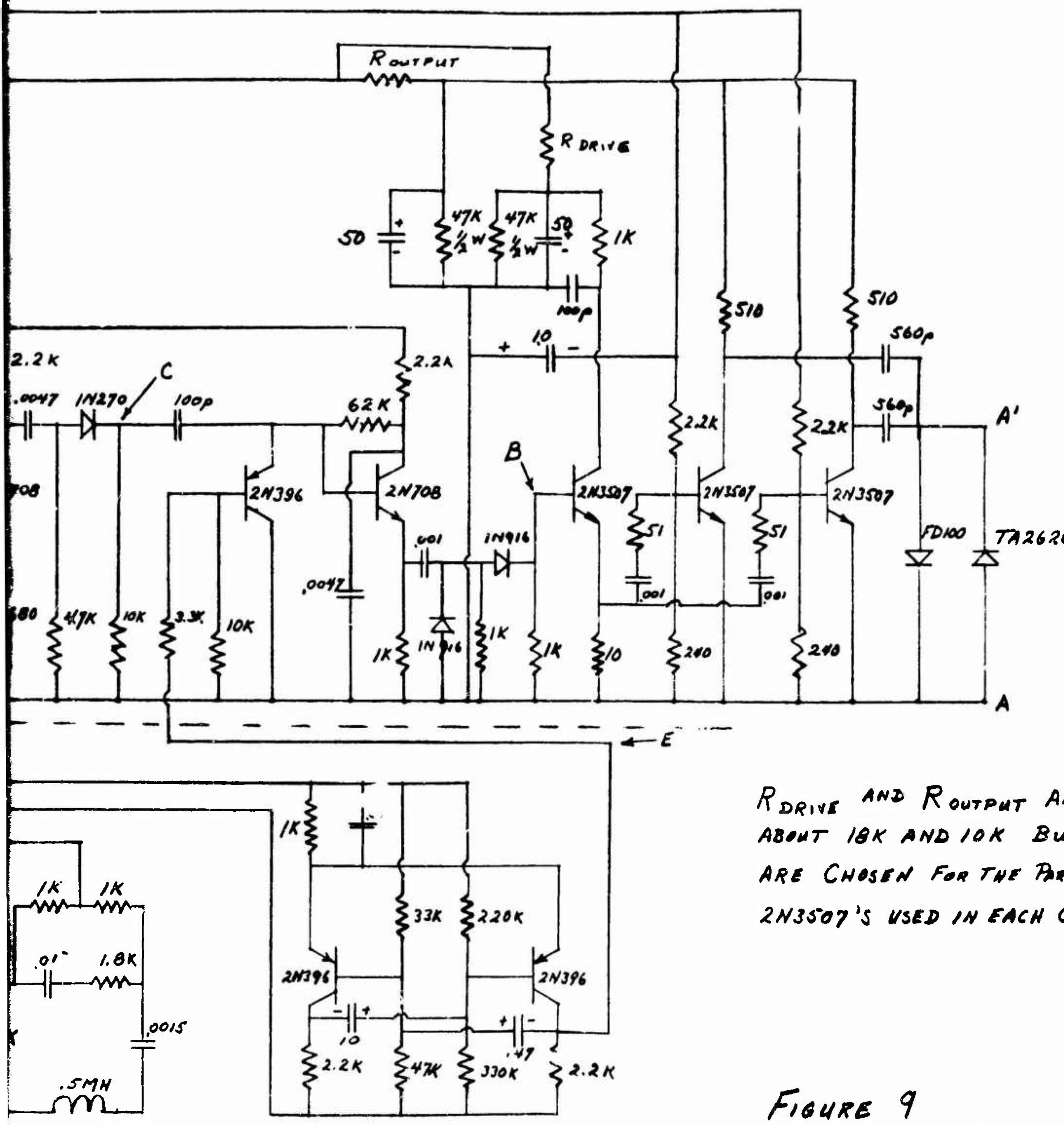



R DRIVE AND R OUTPUT ARE ABOUT 18K AND 10K BUT ARE CHOSEN FOR THE PARTICULAR 2N3507'S USED IN EACH CIRCUIT.

FIGURE 9
LT-18-357 CIRCUIT

| DATE | ITT Federal LABORATORIES NUTLEY, NEW JERSEY, U.S.A. A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION | SIZE B | CODE IDENT. NO. 90348 |
|---|---|---|---|
| 5-1-67 | | SCALE | SHEET 1 OF 3 |
| 5-1-67 | | | |
| 5-1-67 | | | |

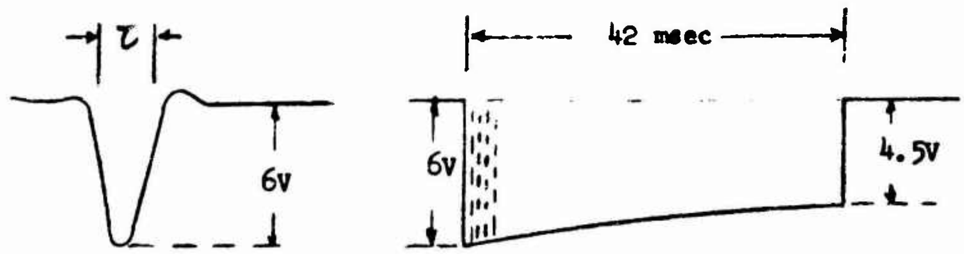



FIG. 10 - OUTPUT PULSE ACROSS 0.9-Ohm RESISTOR (AA' of Fig. 9)
$\tau$ = ~5 n sec (see text)

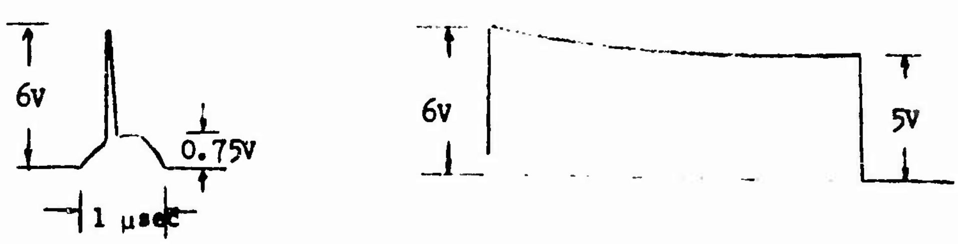



FIG. 11 - PULSE WAVEFORM AT POINT B (Fig. 9)

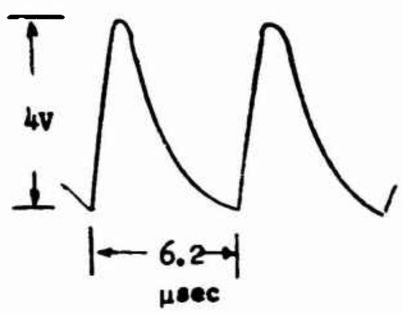



FIG. 12 - WAVEFORM AT POINT C OF FIG. 9

(No telemetry signal applied)

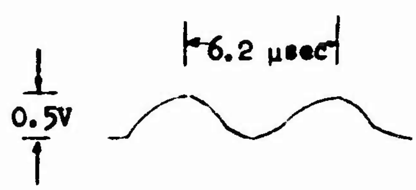



FIG. 13 - WAVEFORM AT POINT D OF FIG. 9

(No telemetry signal applied)

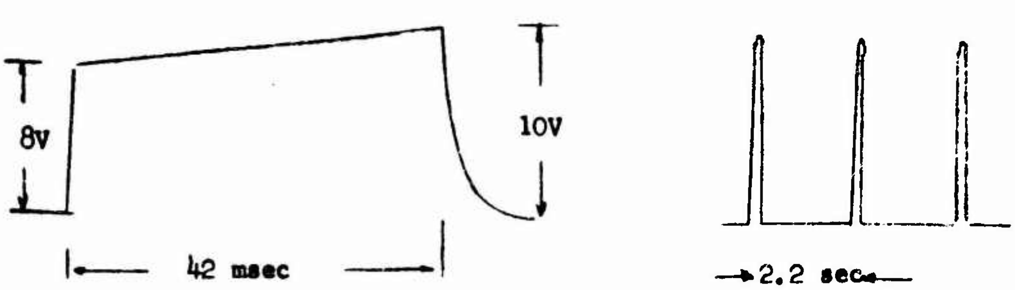
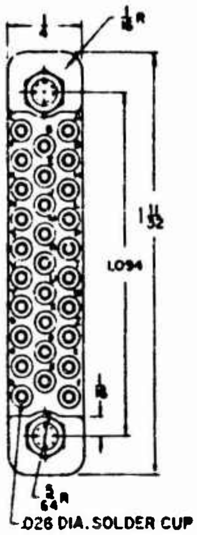



FIG. 14 - WAVEFORM AT POINT E OF FIG. 9




Male

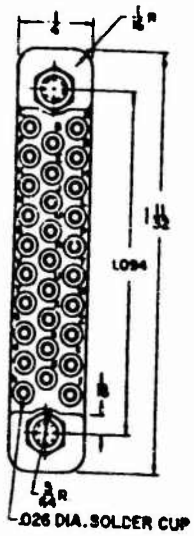
Female

## UNIT TERMINAL IDENTIFICATION LIST

(ITT Federal Labs)

| | |
|---|---|
| A | +27.5V to Vector Unit |
| B | +27.5V From Battery |
| C | Chassis Ground (through Vector Unit) |
| D | Battery & System Ground |
| E | +15.6 to Pin No.1 Potted Circuit |
| F | +27.5V to DC-DC Converter |
| H | +15.6V From Battery |
| J | INPUT to Channel No. 3 - 0.73 kc |
| K | INPUT to Channel No. 1 - 0.40 kc |
| L | INPUT to Channel No. 5 - 1.3 kc |
| M | INPUT to Channel No. 9 - 3.9 kc |
| N | INPUT to Channel No. 7 - 2.3 kc |
| P | INPUT to Channel No. 11 - 7.35 kc |
| R | INPUT to Channel No. 15 - 30.0 kc |
| S | INPUT to Channel No. 13 - 14.5 kc |
| T | INPUT to Channel No. 17 - 52.5 kc |
| U | - 9.6V to Pin No. 2 Potted Circuit |
| V | N. C. |
| W | INPUT to Channel No. 16 - 40.0 kc |
| X | INPUT to Channel No. 14 - 22.0 kc |
| Y | - 9.6V From Battery |
| Z | INPUT to Channel No. 18 - 70.0 kc |
| a | INPUT to Channel No. 8 - 3.0 kc |
| b | INPUT to Channel No. 12 - 10.5 kc |
| c | INPUT to Channel No. 10 - 5.4 kc |
| d | INPUT to Channel No. 2 - 0.56 kc |
| e | INPUT to Channel No. 6 - 1.7 kc |
| f | INPUT to Channel No. 4 - 0.96 kc |
| h | N. C. |

Figure 16




Male

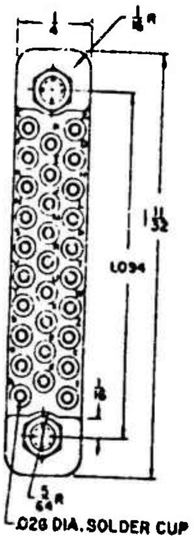
Female

## OPERATING JUMPER PLUG

(ITT Federal Labs)

| | | | | |
|---|---|---|---|---|
| A | | | | |
| B | | | | |
| D | Signal Ground | | | |
| E | | | | |
| F | | | | |
| H | | | | |
| J | INPUT to Channel No. | 3 | - | 0.73 kc |
| K | INPUT to Channel No. | 1 | - | 0.40 kc |
| L | INPUT to Channel No. | 5 | - | 1.3 kc |
| M | INPUT to Channel No. | 9 | - | 3.9 kc |
| N | INPUT to Channel No. | 7 | - | 2.3 kc |
| P | INPUT to Channel No. | 11 | - | 7.35 kc |
| R | INPUT to Channel No. | 15 | - | 30.0 kc |
| S | INPUT to Channel No. | 13 | - | 14.5 kc |
| T | INPUT to Channel No. | 17 | - | 52.5 kc |
| U | | | | |
| W | INPUT to Channel No. | 16 | - | 40.0 kc |
| X | INPUT to Channel No. | 14 | - | 22.0 kc |
| Y | | | | |
| Z | INPUT to Channel No. | 18 | - | 70.0 kc |
| a | INPUT to Channel No. | 8 | - | 3.0 kc |
| b | INPUT to Channel No. | 12 | - | 10.5 kc |
| c | INPUT to Channel No. | 10 | - | 5.4 kc |
| d | INPUT to Channel No. | 2 | - | 0.56 kc |
| e | INPUT to Channel No. | 6 | - | 1.7 kc |
| f | INPUT to Channel No. | 4 | - | 0.96 kc |

Figure 17




Male

Female

BATTERY CHARGING PLUG

(ITT Federal Labs)

| | |
|---|---|
| B | +27.5V (Orange) |
| D | Ground (Brown) |
| Y | - 9.6V (Green) |

-Other terminals not connected-

FIGURE 18

FIG. 19 - SIDE VIEW OF LASER TELEMETER LT-18-357

ITT LABORATORIES 62912

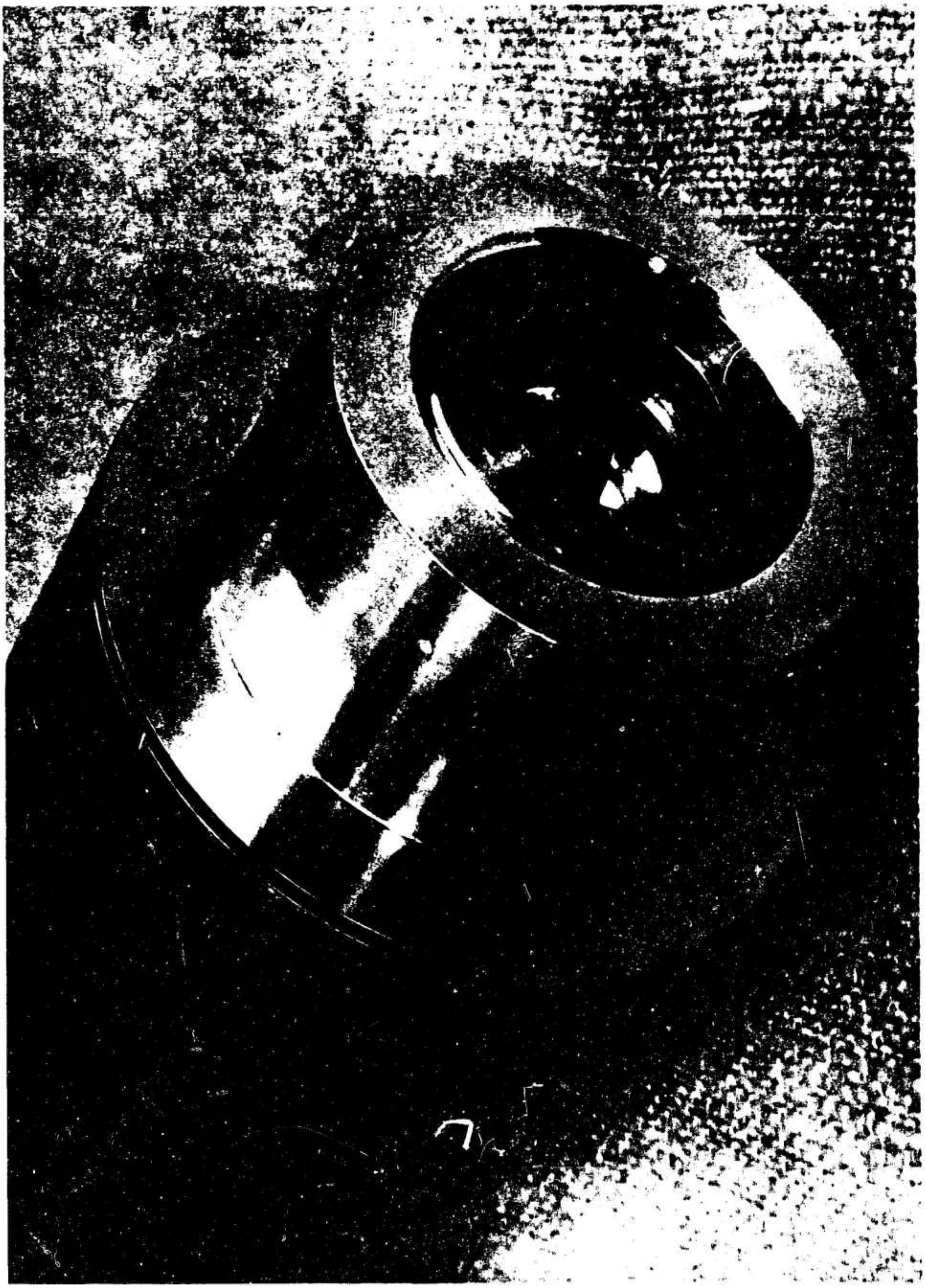
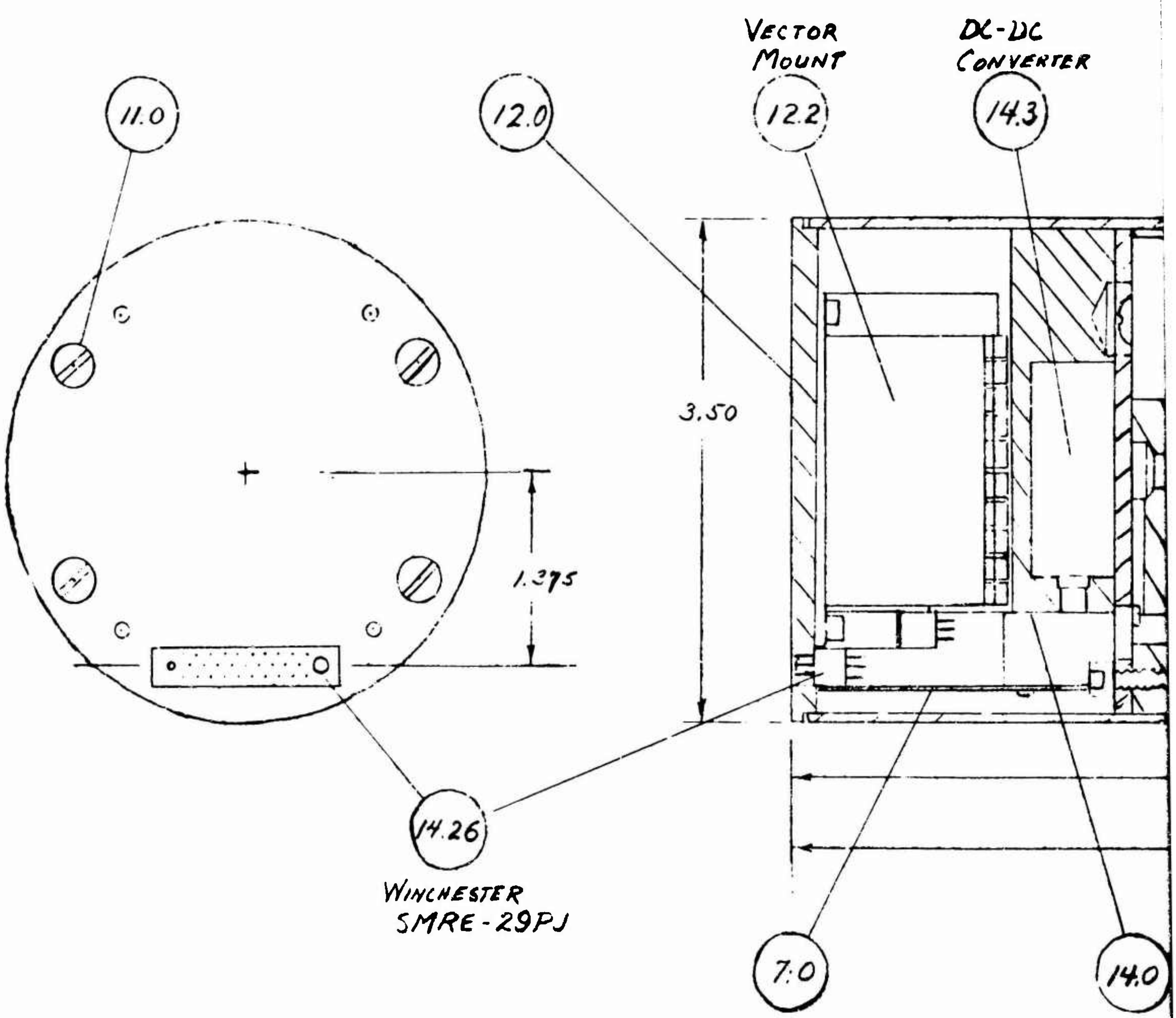


FIG. 20 - TOP VIEW OF LASER TELEMETER LT-18-357

APPENDIX

DETAILED MECHANICAL DRAWINGS

Laser Telemeter Unit LT-18-357




A



| | |
|---|---|
| DRAWN BY W. H. Wallace | DATE 5-2-67 |
| CHECKED BY | DATE |
| APPROVED BY | DATE |

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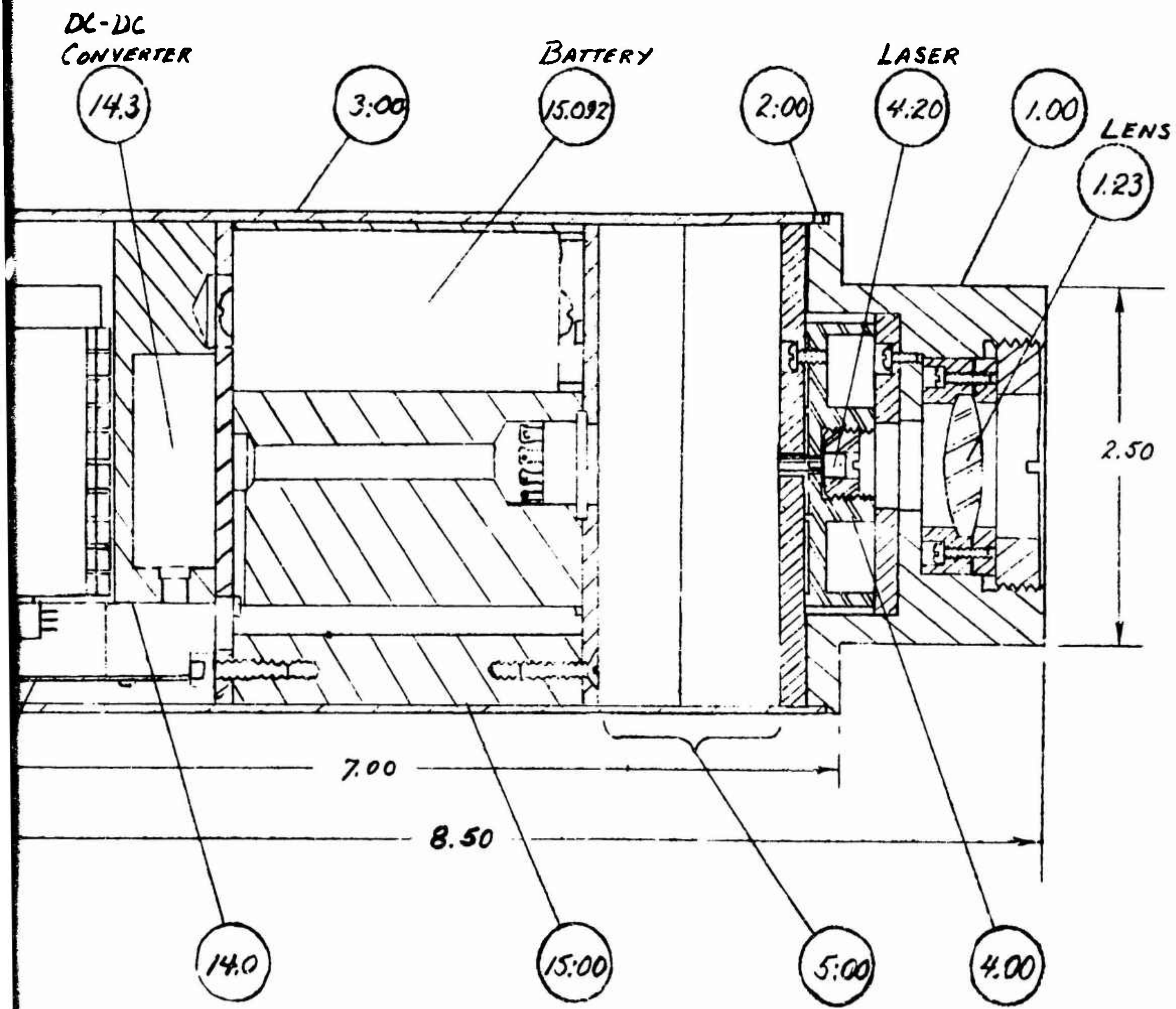



b

- FIG. 15 -

| | | | | |
|---|---|---|---|---|
| DATE 5-2-67 / DATE / DATE | ITT Federal LABORATORIES NUTLEY, NEW JERSEY, U.S.A. A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION | SIZE B | CODE IDENT. NO. 90348 | LT-18-357 |
| | | SCALE | | SHEET 1 OF 7 |

| ITEM | DESCRIPTION | DWG. NO. OR OTHER | ASSEMBLIES PER UNIT | QUANTITY/ ASSEMBLY |
|---|---|---|---|---|
| 0.00.000 | Laser Telemeter | LT-18-357 | - | - |
| 1.00 | Nose - Lens Assembly | -None- | 1 | |
| 1.10 | Jam Nut, Lens | RM 1.75.30-01A | | 1 |
| 1.20 | Lens Assembly | -None- | 1 | |
| 1.21 | Screws | No.2 56 x 5/16 Fil.H.StSt | | 6 |
| 1.22 | Clamp Ring | RM 1.50.19 - 01A | | 1 |
| 1.23 | Lens | 25mm Dia. x 20m F.L (Edmund Scientific 94.340) | | 1 |
| 1.24 | Silastic | Dow Corning "Stops Leaks" | | - |
| 1.25 | Collar | RM 1.50.38 - 01A | | 1 |
| 1.30 | Screws | No.2 56 x 1/4 Pan H. StSt | | 3 |
| 1.40 | Pad, Nose | FM .18321 - 08A | | 1 |
| 1.50 | Nose | RM 3.501.8 - 01A | | 1 |
| 2.00 | Screws | No.2 56 x 1/16 Bristol Set | | 3 |
| 3.00 | Case | T 3.50.065 A-6.78 | | 1 |
| 4.00 | Laser Head Assembly | -None- | 1 | |
| 4.10 | Jam Nut, Laser | | | |
| 4.20 | Laser | RCA Type TA 2628 | | 1 |
| 4.30 | Grease | Silicon Stopcock or Heat-Sink Compound | | - |

PART AND MATERIAL LIST
L1 18-357
2 May 1967



M W Wallace

PART AND MATERIAL LIST
LT-18-357
2 May 1967

| ITEM | DESCRIPTION | DWG. NO. OR OTHER | ASSEMBLIES PER UNIT | QUANTITY/ ASSEMBLY |
|---|---|---|---|---|
| 4.40 | Sleeve | 5/16" Lg Penntube AWG20TW | | 1 |
| 4.50 | Screw | No.2 56 x 1/4 PanH.StSt | | 3 |
| 4.60 | Head Flange | FM .1833.4 - 08A | | 1 |
| 4.70 | Head, Cooling | RM 1.98.50 - 08A | | 1 |
| 5.00 | Circuit Assembly | See Inst.Book & Mfg. Inst. | 1 | |
| 5.10 | Silastic | Dow Corning "Stops Leaks" | | - |
| 5.20 | Screw | No.6 32 x 1-1/4 PanH. StSt | | 4 |
| 5.30 | Lower Deck Assembly | -None- | 1 | |
| 5.31 | Potting | High-Temp. 40%,RCM-2 60%CA-S | | - |
| 5.32 | Nickel Ribbon | .010 x .030 or Equiv. | | - |
| 5.33 | Top Disc | FM .0323.37 - 01A Item 3 | | 1 |
| 5.34 | Bushing | RM .250A - 01A Item 1 | | 4 |
| 5.35 | Nickel Ribbon | .010 x .030 or Equiv. | | - |
| 5.36.00 | Components | Weldable if possible | - | - |
| .10 | Plug | Alden No. 904MB | | 1 |
| .20 | Integrated Circuit | RCA No. CA3000 | | 1 |
| .30 | Transistor | 2N396 | | 2 |
| .40 | Inductor | .5MH Delvan No.2534-16 | | 1 |
| .50 | Capacitors | - | - | - |
| .51 | | .001 MF 200 V - CK05CW102K | | 1 |
| .52 | | .0015MF 200V - CK06CW152K | | 2 |
| .53 | | .01 MF 200V - CK06CW103K | | 2 |
| .54 | | .47 MF 35V - CS13BF474K | | 1 |
| .55 | | 1.0 MF 35V - CS13BF105K | | 2 |
| .56 | | 10.0 MF 25V - TI-4T301 | | 1 |



MMH

PART AND MATERIAL LIST
LT-18-357
2 May 1967

| ITEM | DESCRIPTION | DWG. NO. OR OTHER | ASSEMBLIES PER UNIT | QUANTITY/ ASSEMBLY |
|---|---|---|---|---|
| 5.36.600 | Resistors | 1/4W Unless Specified | | |
| .601 | | 330-Ohm 1/4-W | | 1 |
| .602 | | 1KOhm 1/4-W | | 4 |
| .603 | | 1.2KOhm 1/4-W | | 2 |
| .604 | | 1.8KOhm 1/4-W | | 1 |
| .605 | | 2.2KOhm 1/4-W | | 2 |
| .606 | | 10.0KOhm 1/4-W | | 2 |
| .607 | | 33.0KOhm 1/4-W | | 1 |
| .608 | | 47.0KOhm 1/4-W | | 1 |
| .609 | | 220.0KOhm 1/4-W | | 1 |
| .610 | | 330.0KOhm 1/4-W | | 1 |
| 5.37.0 | Bottom Disc | FM .0323.37 - 01A Item 4 | | 1 |
| 5.40 | Upper Deck Assembly | -None- | 1 | |
| 5.41 | Potting | High Temp CA-S (60%) | - | - |
| | | High Temp RCM-2 (40%) | - | - |
| 5.42 | Top Disc | FM .0323.37 - 01A Item 1 | | 1 |
| 5.43 | Nickel Ribbon | .010 x .030 | | - |
| 5.44 | Bushing | RM .250A - 01A Item 2 | | 4 |
| 5.45.0 | Components | All weldable if possible | | |
| .1 | Socket | Elco 05-3303 (Mod.) | | 1 |
| .2 | Diode | IN270 | | 1 |
| | | 1N916 | | 2 |
| | | FD100 | | 1 |
| .3 | Transistor | 2N3507 Selected | | 3 |
| | | 2N708 | | 2 |
| | | 2N396 | | 1 |



M.M.W.

| ITEM | DESCRIPTION | DWG. NO. OR OTHER | ASSEMBLIES PER UNIT | QUANTITY/ ASSEMBLY |
|---|---|---|---|---|
| 5.45.40 | Capacitors | | | |
| .41 | | 100pf 200V CK05CW101K | | 2 |
| .42 | | 560pf 200V CK05CW561K | | 2 |
| .43 | | .001MF 200V CK05CW102K | | 3 |
| .44 | | .0047MF 200V CK06CW472K | | 2 |
| .45 | | .01MF 200V CK06CW103K | | 1 |
| .46 | | 1.0MF 35V CS13BF105K | | 1 |
| .47 | | 25.0MF 125V CL65CP250MP3 | | 4 |
| 5.45.500 | Resistors | 1/4-Watt Unless Specified | | |
| .501 | | 10-Ohm | | 1 |
| .502 | | 51-Ohm | | 2 |
| .503 | | 240-Ohm | | 2 |
| .504 | | 680-Ohm | | 1 |
| .505 | | 1K-Ohm | | 4 |
| .506 | | 2.2K-Ohm | | 4 |
| .507 | | 3.3K-Ohm | | 1 |
| .508 | | 4.7K-Ohm | | 1 |
| .509 | | 10.0K-Ohm | | 3 |
| .510 | | ~ 12K-Ohm for R Output | | 1 |
| .511 | | ~ 18K-Ohm for R Drive | | 1 |
| .512 | | 27.0K Ohm | | 1 |
| .513 | | 47.0K Ohm - 1/2-Watt | | 2 |
| .514 | | 62.0K Ohm | | 1 |
| 5.46 | Bottom Disc | FM .0323.37 - 01A Item 2 | | 1 |
| 6.0 | Screws | No.2 - 56 x 1/4 PanH. StSt | | 4 |
| 7.0 | Plate | FM .0202.00 - 01A | | 1 |
| 8.0 | Silastic | Dow-Corning "Stops Leaks" | | - |
| 9.0 | Heat-Shrinkable Tubing | | | - |
| 10.0 | Solder | | | - |
| 11.0 | Screws | No.8 - 32 x 1/4 F.H. StSt | | 4 |

| ITEM | DESCRIPTION | DWG. NO. OR OTHER | ASSEMBLIES PER UNIT | QUANTITY/ ASSEMBLY |
|---|---|---|---|---|
| 12.0 | Header Assembly | -None- | 1 | |
| 12.1 | Screws | No.4 - 40 x 1/4 Lg AllenCap | | 4 |
| .2 | Mount | Vector MMM 654-20 | | 1 |
| .3 | Mixer-Amplifier | Vector MMA-11 | | 1 |
| .4.01 | SCO Channel No. 1 | Vector MMO-11 | | 1 |
| .02 | " 2 | | | 1 |
| .03 | " 3 | | | 1 |
| .04 | " 4 | | | 1 |
| .05 | " 5 | | | 1 |
| .06 | " 6 | | | 1 |
| .07 | " 7 | | | 1 |
| .08 | " 8 | | | 1 |
| .09 | " 9 | | | 1 |
| .10 | " 10 | | | 1 |
| .11 | " 11 | | | 1 |
| .12 | " 12 | | | 1 |
| .13 | " 13 | | | 1 |
| .14 | " 14 | | | 1 |
| .15 | " 15 | | | 1 |
| .16 | " 16 | | | 1 |
| .17 | " 17 | | | 1 |
| .18 | " 18 | | | 1 |
| 12.5 | Header | FM .1873.5 - 01A | | 1 |
| 13.0 | Screw | No.8 - 32 x 1/2 F.H. StSt | | 4 |
| 14.0 | Converter Block Assembly | -None- | 1 | |
| .1 | Potting | High-Temp CA-S (60%) | | - |
| | | High-Temp RCM-2 (40%) | | - |
| .20 | Connectors, Wired | | | |
| .21 | Silastic | Dow-Corning "Stops Leaks" | | - |
| | Solder | | | - |
| .22 | Wire | No.26 Std. Teflon Insu. | | - |
| .23 | Screws | No.2 56 x 1/4 Fil.H. StSt | | 2 |
| .24 | Connector | Winchester SMRE 29S | | 1 |
| .25 | Lock-Tite | | | - |
| .26 | Connector | Winchester SMRE 29PJ (Mod.) | | 1 |

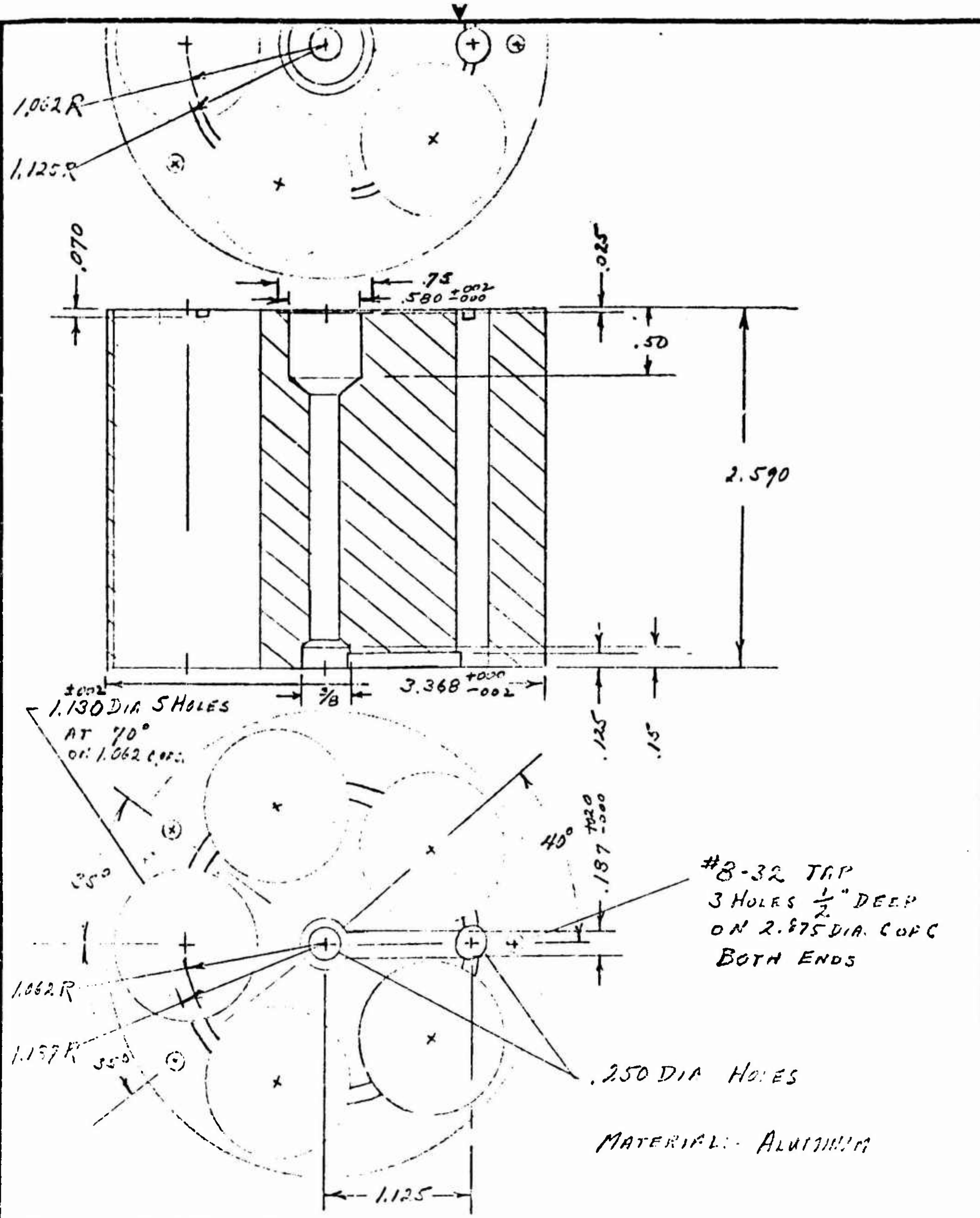
 MW

PART AND MATERIAL LIST
LT-18-357
2 May 1967

| ITEM | DESCRIPTION | DWG. NO. OR OTHER | ASSEMBLIES PER UNIT | QUANTITY/ ASSEMBLY |
|---|---|---|---|---|
| 14.3 | DC-DC Converter | Transformer Electronics No. 2491-000 | | 1 |
| 14.4 | Converter Block | RM 3.372.2 - 01A | | 1 |
| 14.5 | Screws | No.8 - 32 x 5/8 PanH. | | 2 |
| 14.6 | Screws | No.8 - 32 x 3/8 Fil.Hd. | | 2 |
| 15.00 | Battery Assembly | -None- | 1 | |
| .01 | Screw | No.8 - 32 x 1/2 Allen Cap | | 1 |
| .02 | Lower Bulkhead | FM .1253.4 - 02A | | 1 |
| .03 | Potting | High-Temp CA-S (60%) | | - |
| | | High-Temp RCM-2 (40%) | | - |
| .04 | Wire | | | |
| .05.1 | Spacer | TM 1.13.063 - 01A Item 1 | | 5 |
| .2 | | Item 2 | | 1 |
| .3 | | Item 3 | | 1 |
| .4 | | Item 4 | | 2 |
| .06 | Screws | No.8 - 32 F.H. StSt x 1/2 Lg. | | 3 |
| .07 | Upper Bulkhead | FM .1253.4 - 02A | | 1 |
| .080 | Socket Assembly | -None- | 1 | |
| .081 | Silastic | Dow Corning "Stops Leaks" | | - |
| .082 | Solder | | | |
| .083 | Wire | No.26 - Strd. Teflon Inv. | | - |
| .084 | Socket | Alden 407 | | 1 |
| 15.091 | Battery | Gulton 5V 0.180P | | 2 |
| .092 | | Gulton 7V 0.180P | | 1 |
| .093 | | Gulton 6V 0.180P | | 1 |
| .094 | | Gulton 8V 0.080P | | 1 |
| 15.10 | Block, Battery | RM 3.372.6 - 01A | | 1 |



MW




| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS | BLOCK, BATTERY |
|---|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | | |

| USED ON | CODE IDENT. NO. | DWG. SIZE | |
|---|---|---|---|
| PREPARED BY [illegible] DATE 2-27-67 | 90348 | A | RM 3.372.6-01A |
| CHECKED BY DATE | | | SHEET |

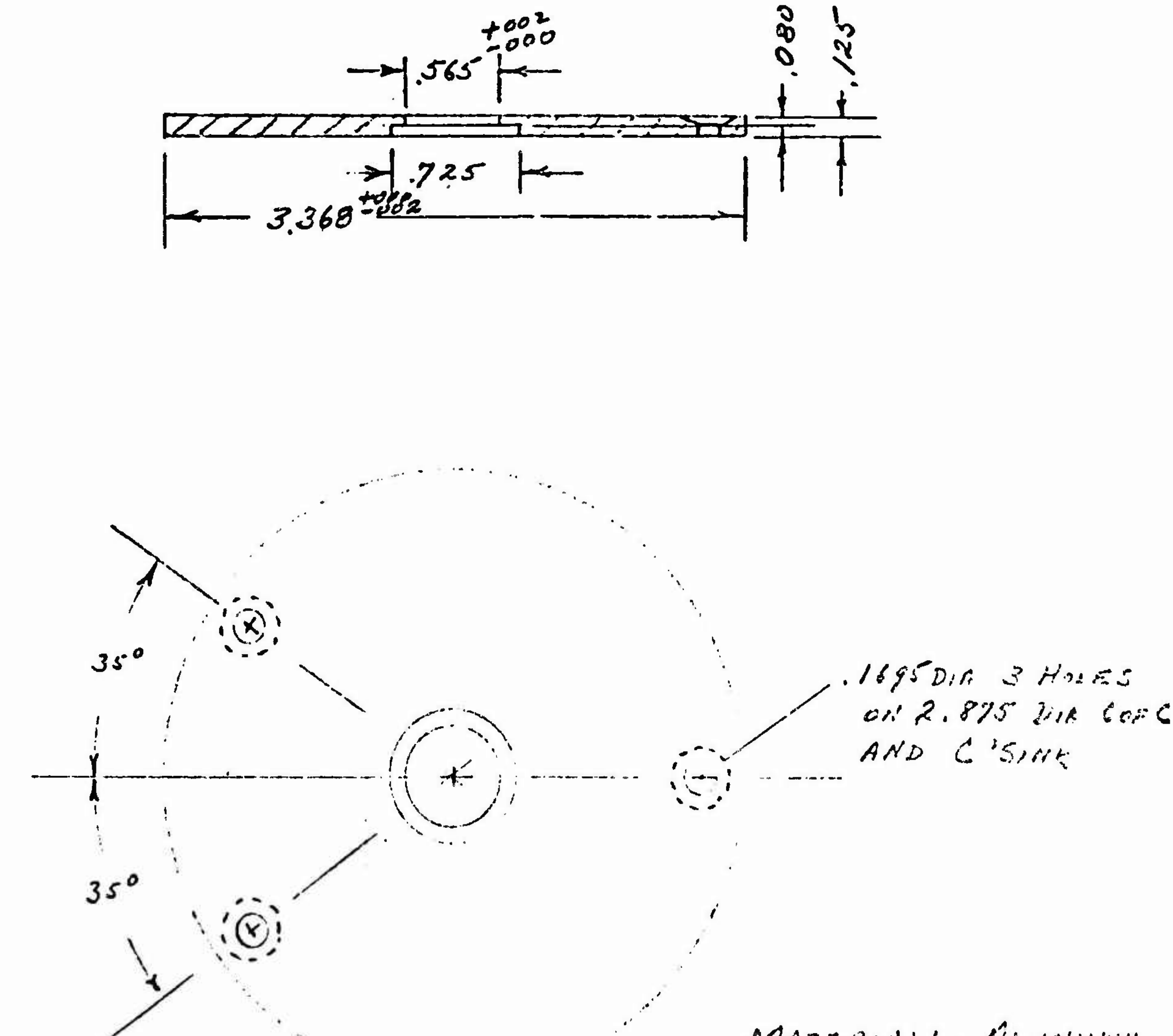
ITT Federal LABORATORIES A DIV. OF INT. TEL. & TEL. CORP.

DRAWING NUMBER



ITTFL D15 (X) REV. 6/64

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. REPROVEL NO. 440M




MATERIAL: - ALUMINUM

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS | |
|---|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | | BULKHEAD, UPPER |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | | |

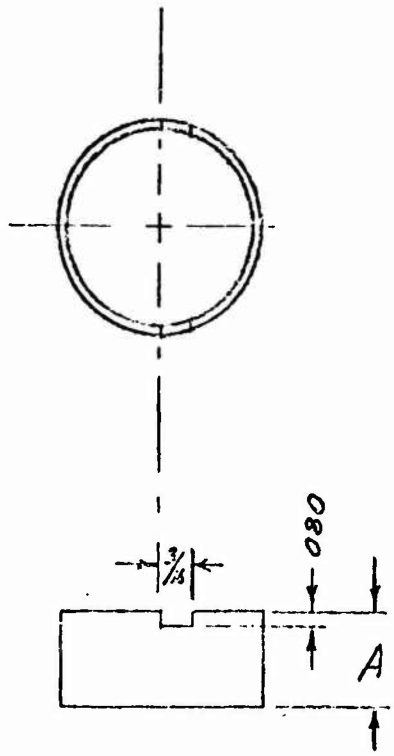
| USED ON | CODE IDENT. NO. | DWG. SIZE | |
|---|---|---|---|
| PREPARED BY [illegible] DATE 2-27-67 | 90348 | A | FM.12534-02A |
| CHECKED BY DATE | | | SHEET |

ITT Federal LABORATORIES
A DIV. OF INT. TEL. & TEL. CORP.

ITTFL DI5 (X) REV. 6/64

DRAWING NUMBER






| ITEM | A | REQ PER UNIT |
|---|---|---|
| 1 | .185 | 5 |
| 2 | .300 | 1 |
| 3 | .400 | 1 |
| 4 | .600 | 2 |

MATERIAL: PHENOLIC, LAM. NAT TUBE GRADE E
1 1/8 OD × 1/16 WALL

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

SPACER

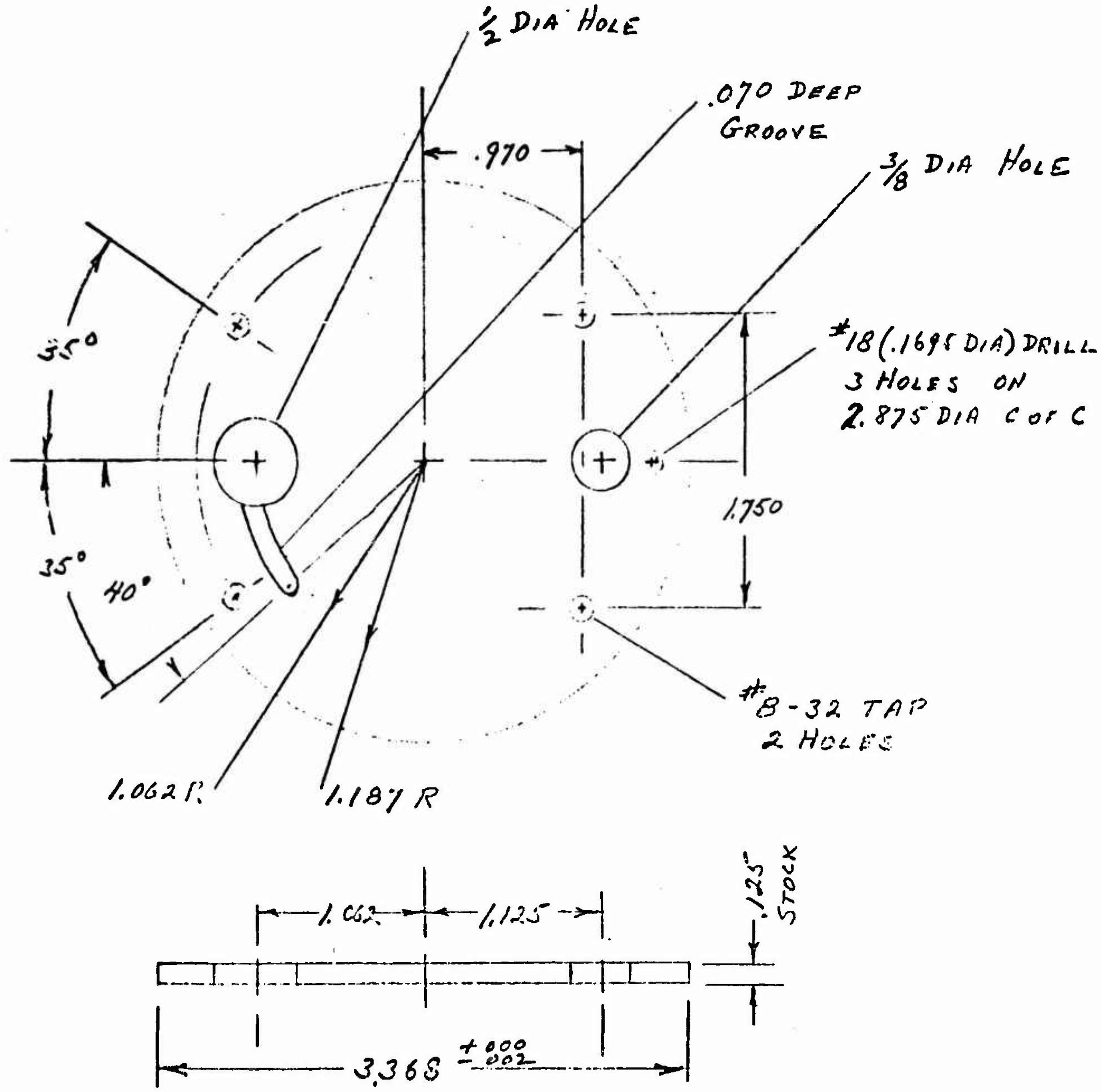
ITT Federal LABORATORIES
A DIV. OF INT. TEL. & TEL. CORP.

| USED ON | CODE IDENT. NO. | DWG SIZE | |
|---|---|---|---|
| PREPARED BY [illegible] DATE 2-27-67 | 90348 | A | TM 1.13.063-01A |
| CHECKED BY DATE | | | SHEET |

ITTFL D15 (X) REV. 6/64

DRAWING NUMBER






MATERIAL:- ALUMINUM

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

BULKHEAD, LOWER

| USED ON | CODE IDENT. NO. | DWG. SIZE | |
|---|---|---|---|
| PREPARED BY M. [illegible] DATE 2-27-67 | 90348 | A | FM.1253.4-02A |
| CHECKED BY DATE | | | SHEET |

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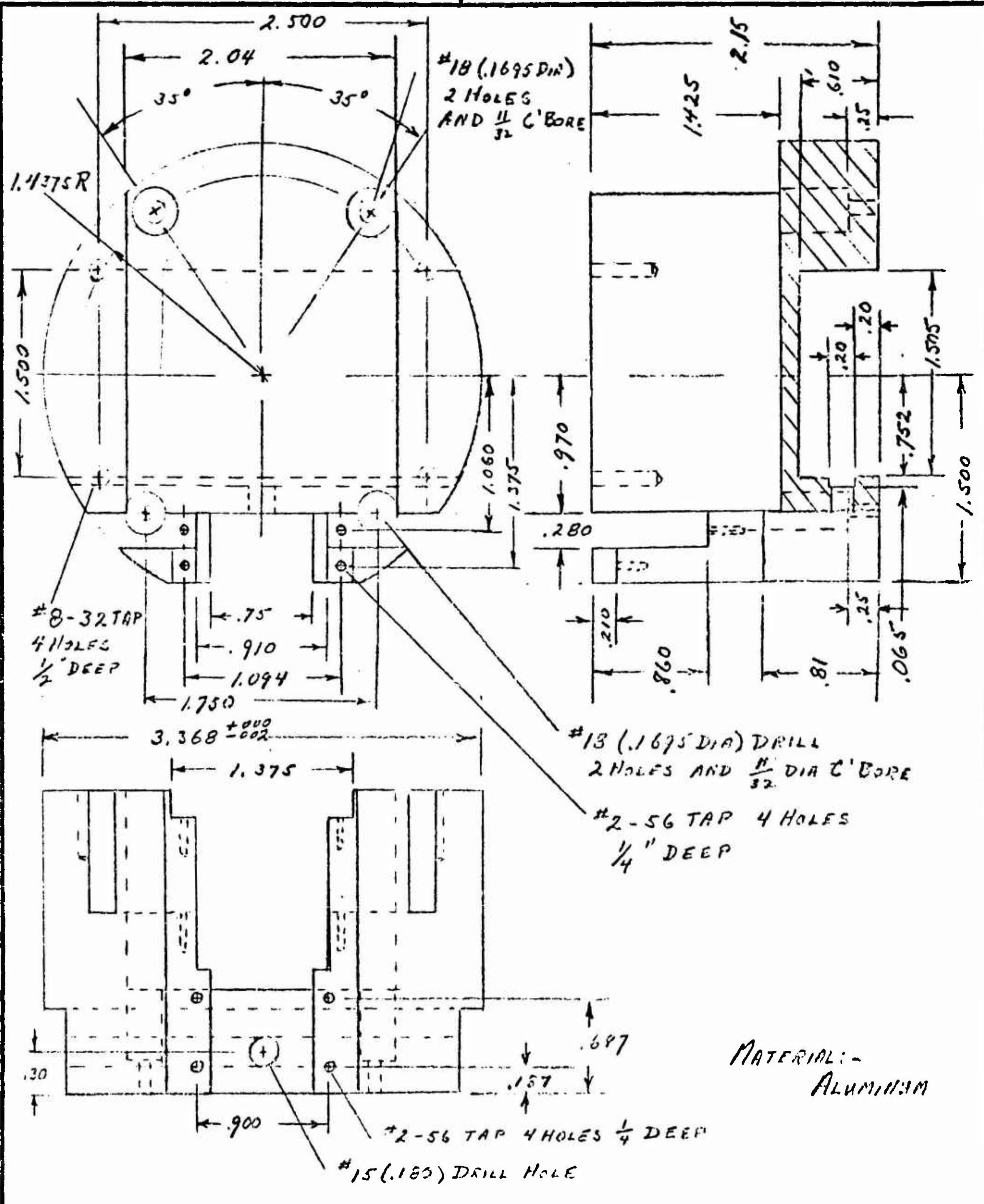
A DIV. OF INT. TEL. & TEL. CORP.




ITTEL D15 (X) REV. 6/64

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ITT Federal LABORATORIES
A DIV. OF INT. TEL. & TEL. CORP.

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

CONVERTER BLOCK

USED ON

PREPARED BY [illegible] DATE 2-2-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

RM 3.372.2-01A

SHEET

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. REPROVEL NO. 440M

ITTFL DWG (X) REV. 6/64

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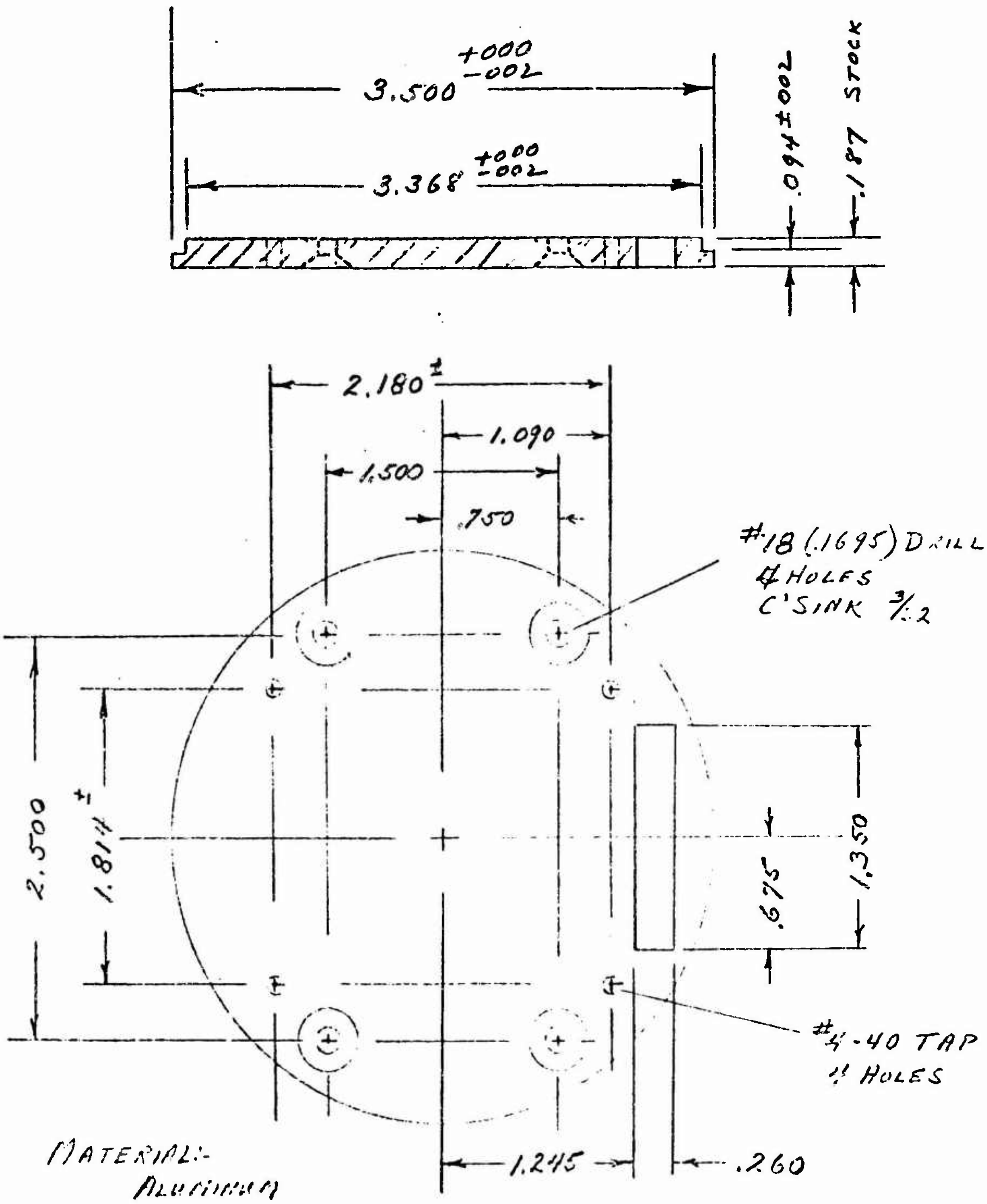


| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

HEADER

| USED ON | CODE IDENT. NO. | DWG. SIZE | |
|---|---|---|---|
| PREPARED BY [illegible] DATE 3-3-67 | 90348 | A | FM 18735-01A |
| CHECKED BY DATE | | | SHEET |

ITTFL 013 (R) REV. 6/54

DRAWING NUMBER

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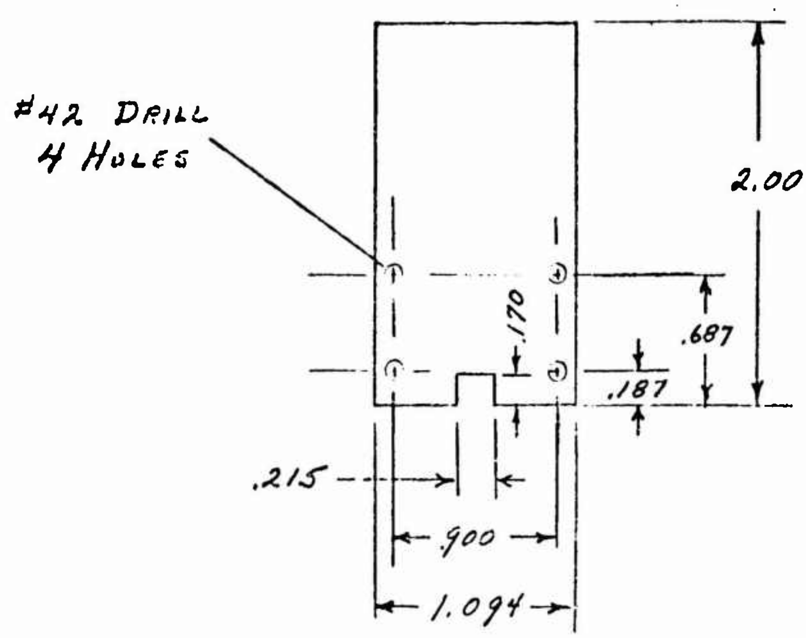
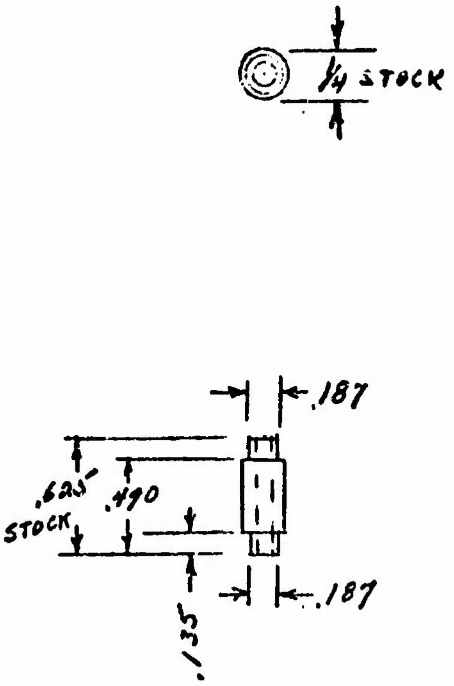



MATERIAL: .020" THICK ALUMINUM

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS | PLATE |
|---|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | | |

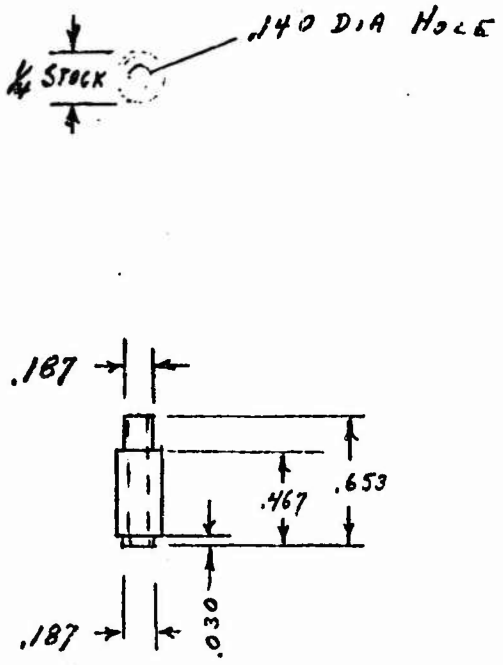
| | | | |
|---|---|---|---|
| USED ON | CODE IDENT. NO. 90348 | DWG. SIZE A | FM .020 2.00-01A |
| PREPARED BY [illegible] DATE 5-1-67 | | | |
| CHECKED BY DATE | | | SHEET |

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. REPROVEL NO. 440M




MATERIAL:-
1/4 DIA 5/8 LONG
#6-32 TAPPED
BRASS SPACER

ITEM 1




MATERIAL:
1/4 DIA X 3/4 LONG
#6-32 TAPPED
BRASS SPACER

ITEM 2

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

BUSHING

USED ON

PREPARED BY [illegible] DATE 2-22-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

RM .250A - 01A

SHEET

ITTFL 018 (K) REV. 3/64

DRAWING NUMBER

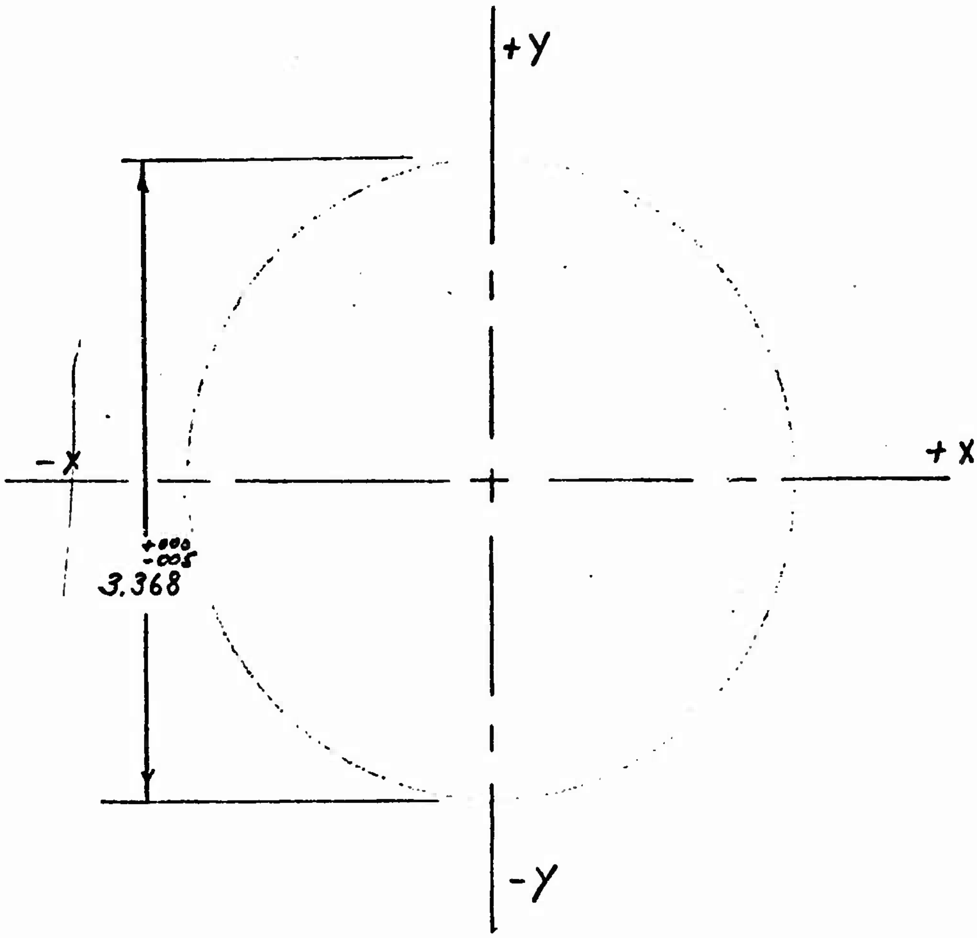


ITT Federal LABORATORIES
A DIV. OF INT. TEL. & TEL. CORP.

ITTFL DIS (X) REV. 6/64

DRAWING NUMBER






| ITEM | |
|---|---|
| 1 | TOP DISC, UPPER DECK |
| 2 | BOTTOM DISC, UPPER DECK |
| 3 | TOP DISC, LOWER DECK |
| 4 | BOTTOM DISC, LOWER DECK |

MATERIAL:- G7 FIBER GLASS 1/32 THICK

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

DISC

USED ON

PREPARED BY [illegible] DATE 3-15-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

FM .032 3.37 - 01A

SHEET 1 OF 7

ITT Federal LABORATORIES
A DIV. OF INT. TEL. & TEL. CORP.

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. REPROVEL NO. 440M

ITFL DIS (X) REV. 6/64

DRAWING NUMBER

# SCHEDULE OF HOLES

ALL HOLE #56 DRILL (        DIA.) UNLESS OTHERWISE SPECIFIED.

| LOCATION X | LOCATION Y | ITEM 1 | ITEM 2 | ITEM 3 | ITEM 4 |
|---|---|---|---|---|---|
| + 3/8 | +1 7/16 | | X | | |
| + 13/32 | " | | | | X |
| + 9/32 | " | | | | X |
| - 1/16 | +1 1/4 | | | X | X |
| + 1/4 | " | | | X | X |
| + 13/32 | " | | | X | X |
| + 19/32 | " | | | X | X |
| - 13/16 | +1 3/16 | 3/16 | 3/16 | 3/16 | 3/16 |
| - 5/8 | " | X | X | X | |
| + 13/16 | " | 3/16 | 3/16 | 3/16 | 3/16 |
| - 1/16 | +1 1/16 | | | X | X |
| + 3/32 | " | | | X | X |
| + 13/32 | " | | | X | X |
| + 19/32 | " | | | X | X |
| + 7/8 | + 1 | | | X | X |
| + 1 | " | X | X | X | X |
| + 1/16 | + 15/16 | | | X | X |
| - 5/8 | + 7/8 | X | X | | |
| + 19/32 | " | | | X | X |
| + 7/8 | " | X | X | | |
| + 1 | " | X | X | | |
| + 1/16 | + 13/16 | | | | X |

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ITT Federal LABORATORIES
A DIV. OF INT. TEL. & TEL. CORP.

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

DISC

USED ON

PREPARED BY [illegible] DATE 3-15-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

FM.032337-01A

SHEET 2 OF 7

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. REPROVEL NO. 440M

ITTFL 015 (X) REV. 6/64

DRAWING NUMBER

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# SCHEDULE OF HOLES (CONT.)

| LOCATION X | LOCATION Y | ITEM 1 | ITEM 2 | ITEM 3 | ITEM 4 |
|---|---|---|---|---|---|
| - 3/4 | + 3/4 | x | x | x | |
| + 1/4 | " | | | | 1/4 |
| + 3/4 | " | x | x | | |
| - 7/16 | + 5/8 | x | x | | |
| + 11/16 | " | | | | x |
| + 1 | " | | 1/8 | | |
| + 1 1/4 | " | x | x | | |
| + 1/2 | + 9/16 | | | | x |
| + 5/8 | " | | | x | |
| - 1 1/8 | + 1/2 | | x | | |
| - 1/4 | " | | x | | |
| - 1/8 | " | | x | | |
| + 1/16 | " | x | | | |
| + 3/4 | " | x | x | | |
| - 1/16 | + 7/16 | | | | x |
| - 3/16 | " | 3/8 | | | |
| + 5/16 | " | | | x | x |
| - 1 | + 3/8 | x | x | | |
| - 9/16 | " | x | x | | |
| - 1/4 | " | | x | | |
| + 1/8 | " | x | x | | |
| + 1/2 | " | | | | x |
| + 5/8 | " | | | x | |
| + 29/32 | " | | x | | |
| + 1 3/32 | " | | x | | |

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

DISC

ITT Federal LABORATORIES
A DIV OF INT TEL. & TEL. CORP.

USED ON

PREPARED BY: M. W. Wilson DATE: 3-15-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

FM 032 3.37-01A

SHEET 3 OF 7

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. REPROVEL NO. 440M

ITTFL DIS (X) REV. 6/64

DRAWING NUMBER

# SCHEDULE OF HOLES (CONT.)

| LOCATION X | LOCATION Y | ITEM 1 | ITEM 2 | ITEM 3 | ITEM 4 |
|---|---|---|---|---|---|
| - 7/8 | + 1/4 | X | X | | |
| - 11/16 | " | X | X | | |
| - 7/16 | " | X | X | | |
| + 1/2 | " | | X | X | X |
| + 5/8 | " | X | X | | |
| + 29/32 | " | | X | | |
| + 1 3/32 | " | | X | | |
| + 3/8 | + 1/8 | | | | X |
| + 1/2 | " | | | X | X |
| - 1 1/8 | + 3/32 | | X | | |
| - 3/4 | " | X | X | | |
| - 7/16 | " | | X | | |
| - 1/4 | " | | X | | |
| + 5/8 | " | X | X | | |
| + 1 | " | | X | | |
| - 1 1/2 | 0 | | X | X | |
| - 1 7/32 | 0 | | X | | |
| - 1 1/8 | 0 | 3/8 | | | |
| 0 | 0 | .358 | 1/4 | 3/8 | .578 |
| + 1/4 | 0 | X | X | | |
| + 1 | 0 | 3/8 | | | |
| + 1 3/32 | 0 | | X | | |
| + 1 1/2 | 0 | | X | X | |



ITT Federal LABORATORIES
A DIV. OF INT. TEL. & TEL. CORP.

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

DISC

USED ON

PREPARED BY [illegible] DATE 3-15-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

FM.022337-011

SHEET 4 OF 7

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. REPROVEL NO. 440M

DRAWING NUMBER

# SCHEDULE OF HOLES (CONT.)

| LOCATION X | LOCATION Y | ITEM 1 | ITEM 2 | ITEM 3 | ITEM 4 |
|---|---|---|---|---|---|
| -1 1/8 | - 3/32 | | X | | |
| - 3/4 | " | X | X | | |
| - 7/16 | " | | X | | |
| - 1/4 | " | | X | | |
| + 5/8 | " | X | X | | |
| + 1 | " | | X | | |
| -1 1/2 | -1/4 | X | X | | |
| -1 1/4 | " | X | X | | |
| -1 1/8 | " | X | X | | |
| - 7/8 | " | X | X | | |
| - 11/16 | " | X | X | | |
| - 7/16 | " | X | X | | |
| + 1/2 | " | | X | | |
| + 5/8 | " | X | X | | |
| + 3/4 | " | X | X | | |
| + 15/16 | " | X | X | | |
| +1 1/8 | " | | X | | |
| - 9/16 | - 3/8 | X | X | | |
| - 1/4 | " | | X | | X |
| - 1/8 | " | | X | | |
| + 1/8 | " | X | X | | |
| + 1/4 | " | | | X | X |
| + 1/2 | " | | | | X |
| +1 1/8 | " | X | X | | |

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS | |
|---|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | | DISC |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | | |

| | | | |
|---|---|---|---|
| USED ON | CODE IDENT. NO. 90348 | DWG. SIZE A | FM 032237-01A |
| PREPARED BY [illegible] DATE 3-15-67 | | | |
| CHECKED BY DATE | | | SHEET 5 OF 7 |



ITT Federal LABORATORIES
A DIV OF INT. TEL. & TEL. CORP.

OGILVIE PRESS, INC., BROOKLYN 17, N. Y. REPROVEL NO. 440M

# SCHEDULE OF HOLES (CONT.)

| LOCATION X | Y | ITEM 1 | ITEM 2 | ITEM 3 | ITEM 4 |
|---|---|---|---|---|---|
| -1 1/4 | -7/16 | x | x | | |
| -1 | " | x | x | | |
| -3/16 | " | 3/8 | | | |
| +1/2 | " | | | 3/8 | |
| -1/8 | -1/2 | | x | | |
| 0 | " | | | x | x |
| +1/16 | " | x | | | |
| +1/8 | " | | | | x |
| +13/32 | " | | | | x |
| +19/32 | " | | | | x |
| 0 | -5/8 | | | x | x |
| +1 | " | | | | 1/8 |
| +1 1/4 | " | | | x | x |
| -3/8 | -3/4 | x | x | | |
| -1/4 | " | x | x | | |
| +3/4 | " | x | x | | |
| +1/4 | -7/8 | | | x | x |
| +1/2 | " | | | | x |
| +3/4 | " | x | x | | |
| +1/2 | -15/16 | | | 3/8 | |
| 0 | -1 | | | x | x |
| +13/32 | " | | | | x |
| +19/32 | " | | | | x |

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

Disc

USED ON

PREPARED BY [illegible] DATE 3-15-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

FM.032237-01A

SHEET 6 of 7

ITTFL DIS (X) REV. 6/64

DRAWING NUMBER

# SCHEDULE OF HOLES (CONT.)

| LOCATION X | Y | ITEM 1 | ITEM 2 | ITEM 3 | ITEM 4 |
|---|---|---|---|---|---|
| -1/4 | -1 1/8 | | | | X |
| 0 | " | | | X | X |
| +1/8 | " | | | | X |
| +1/4 | " | | | X | X |
| -13/16 | -1 3/16 | 3/16 | 3/16 | 3/16 | 3/16 |
| +13/16 | " | 3/16 | 3/16 | 3/16 | 3/16 |
| +3/8 | -1 7/16 | | X | | |



ITT Federal LABORATORIES
A DIV. OF INT. TEL. & TEL. CORP.

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .05 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

DISC

USED ON

PREPARED BY [illegible] DATE 3-15-67

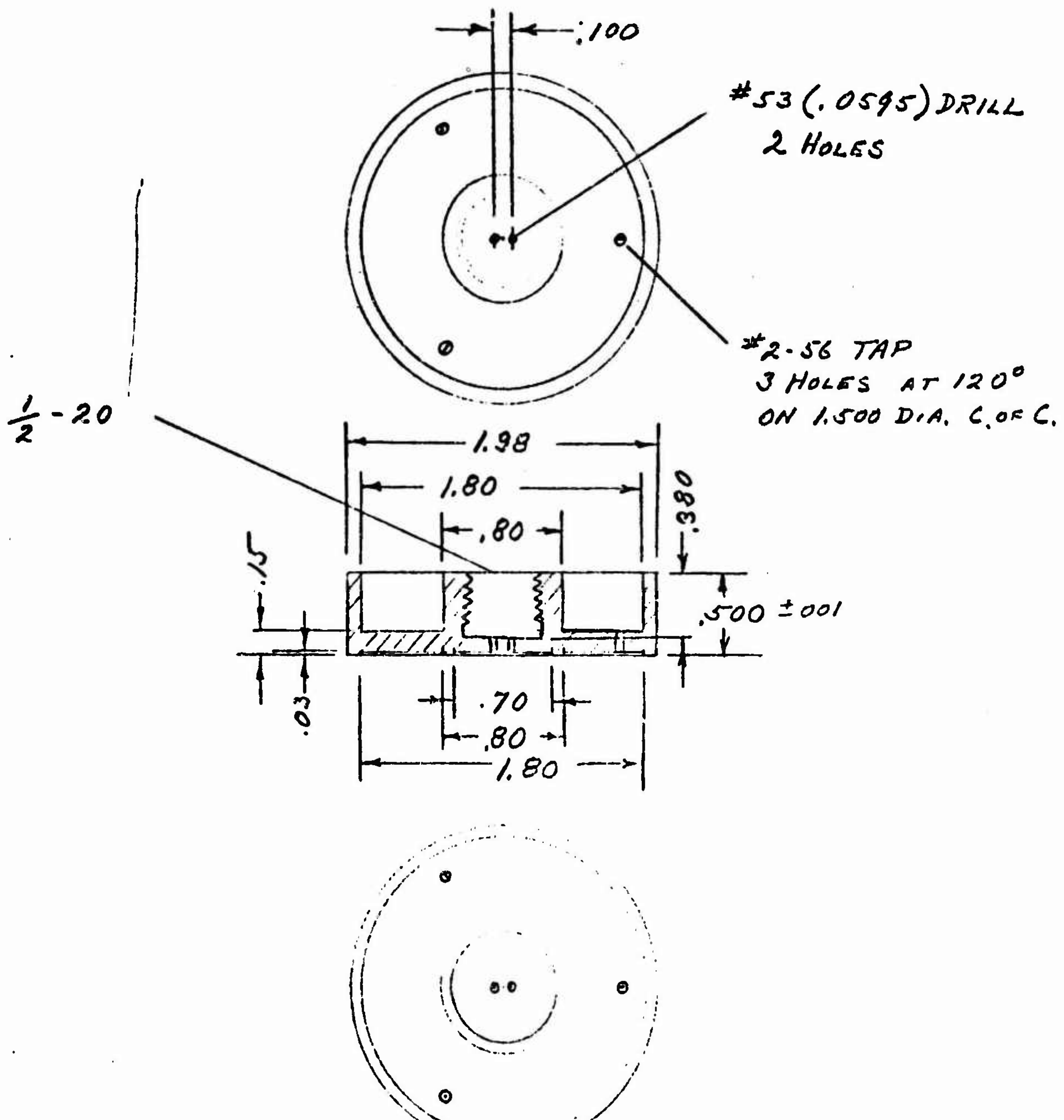
CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

FM.032337-01A

SHEET 7 OF 7




MATERIAL: BRASS

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

HEAD, COOLING

USED ON

PREPARED BY [illegible] DATE 3-6-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. A SIZE

RM1.98.50-08A

SHEET

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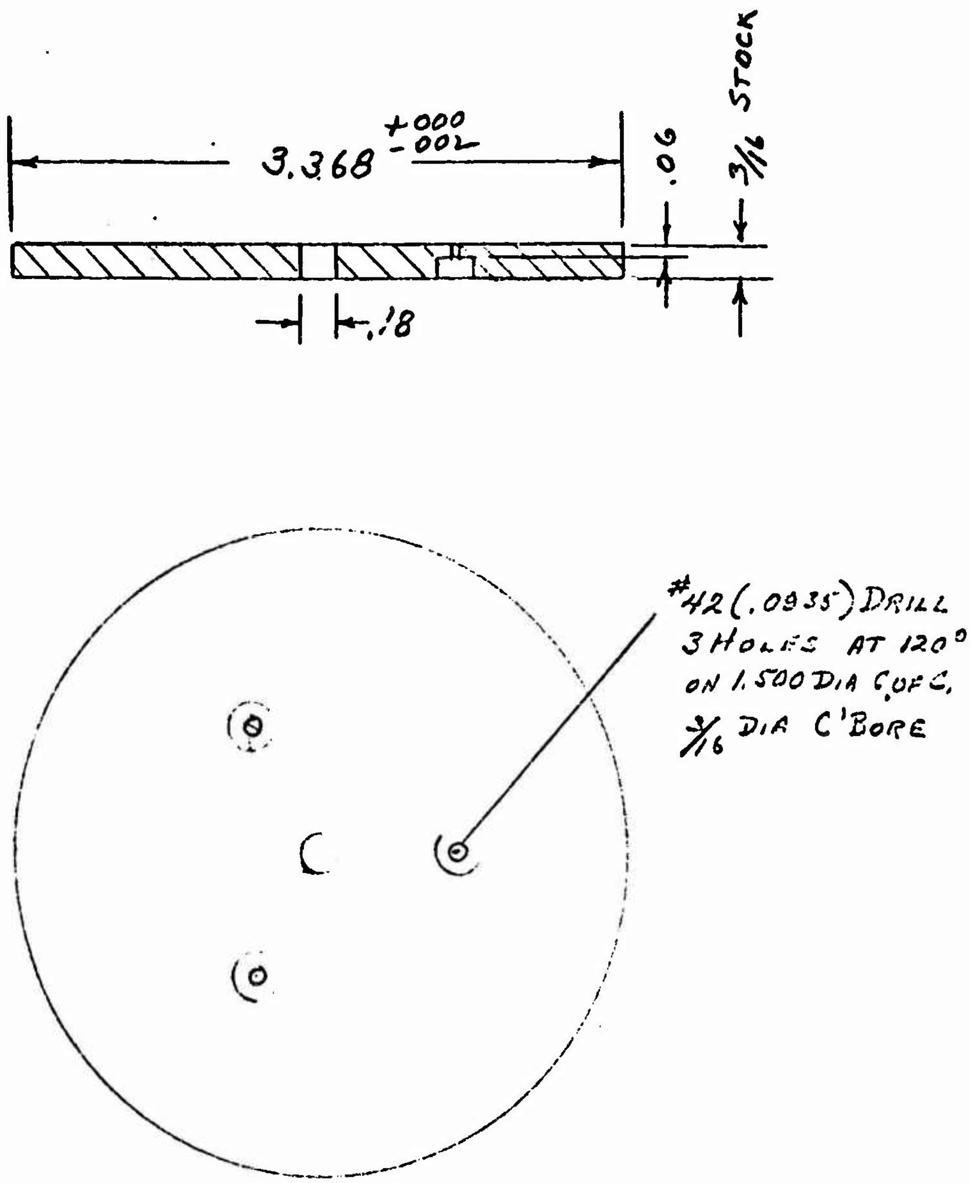
ITFL 015 (K) REV. 6/64




MATERIAL: - G 7 (GLASS CLOTH REENFORCED SILICON) FIBER GLASS

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

HEAD FLANGE

USED ON

PREPARED BY [signature] DATE 3-6-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG SIZE A

FM .183 3.4 - 08A

SHEET

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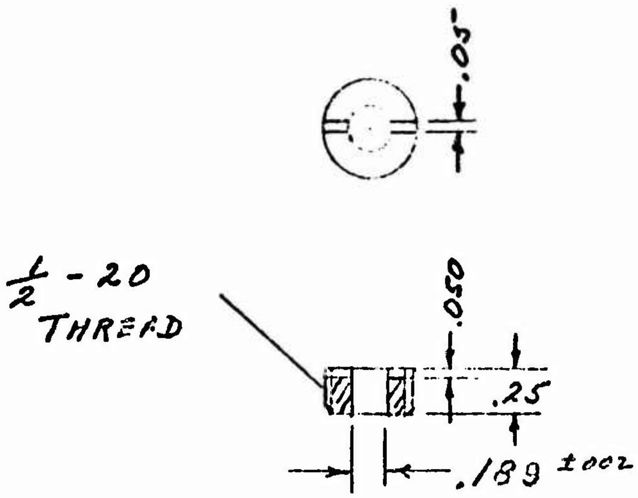
DRAWING NUMBER






MATERIAL :- BRASS

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

JAM NUT, LASER

USED ON

PREPARED BY [illegible] DATE

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CODE IDENT. NO. 90348

DWG. SIZE A

RM.500.25-01A

SHEET

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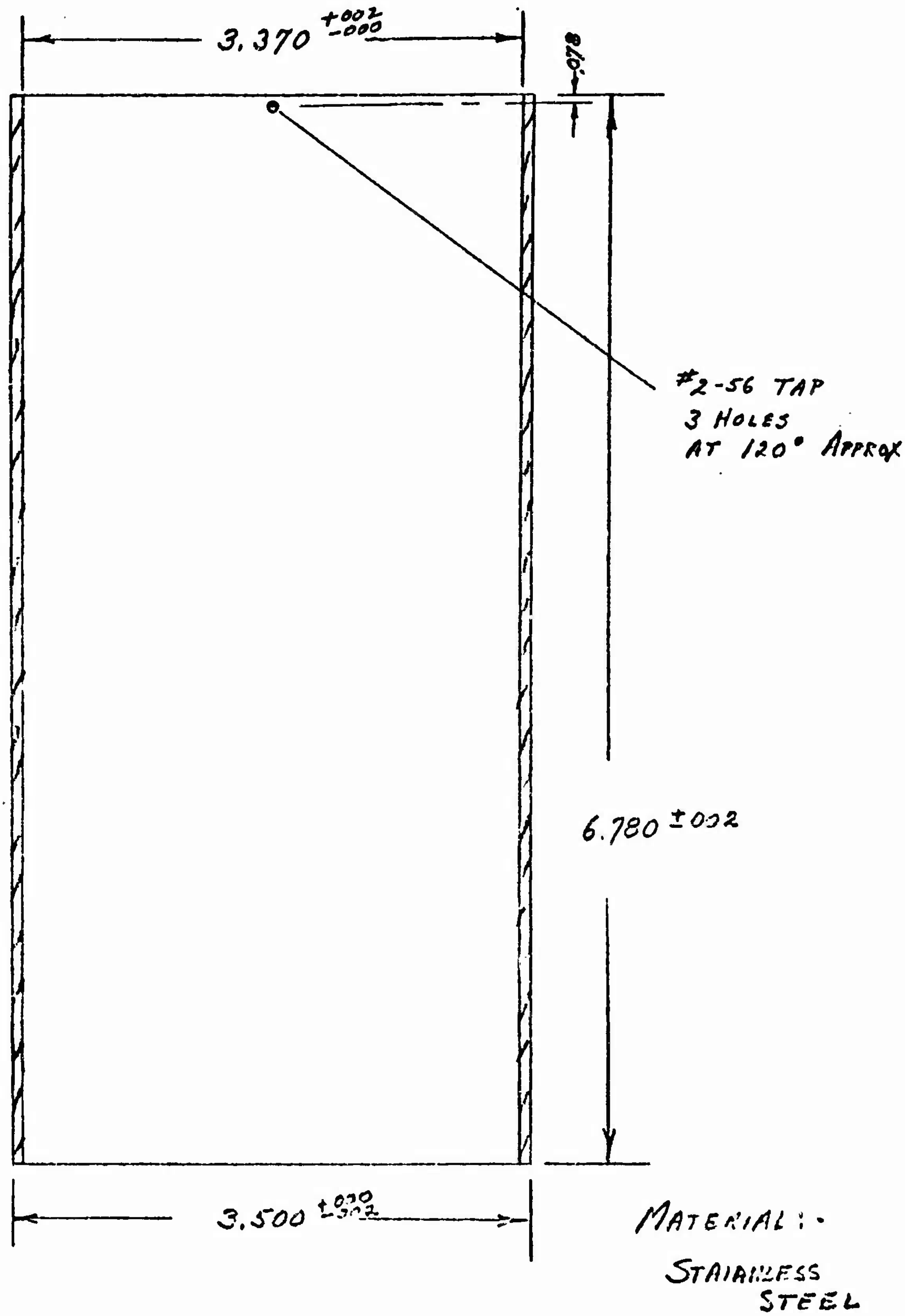



| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

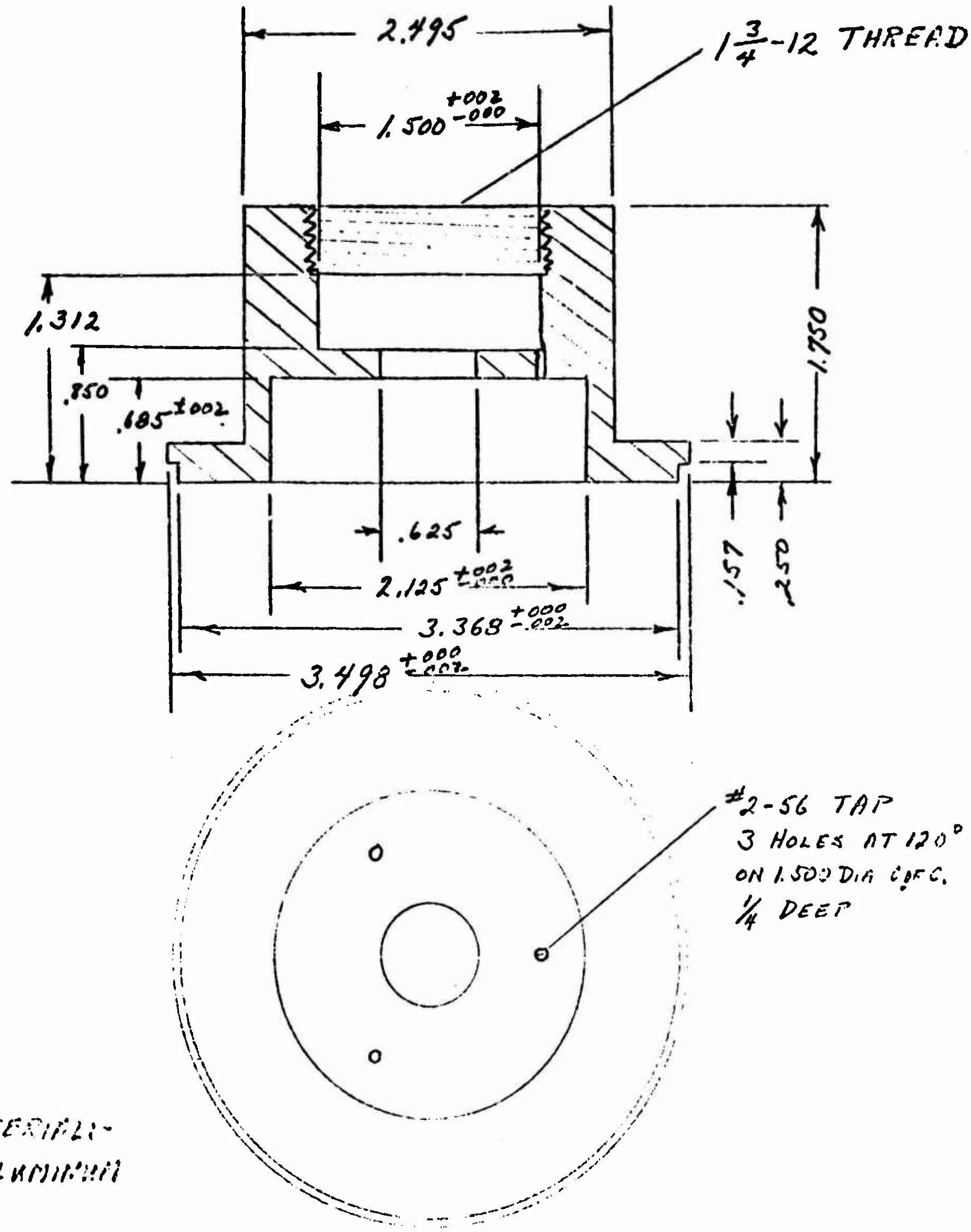
CASE

| USED ON | CODE IDENT. NO. | DWG. SIZE | |
|---|---|---|---|
| PREPARED BY M. [illegible] DATE 3-3-67 | 90348 | A | T 3.50.065A-6.78 |
| CHECKED BY DATE | | | SHEET |

ITTFL 018 (X) REV. 6/64

DRAWING NUMBER






MATERIAL:-
ALUMINUM

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS | NOSE |
|---|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | | |

| USED ON | CODE IDENT. NO. | DWG. SIZE | |
|---|---|---|---|
| PREPARED BY: [illegible] DATE 3-6-67 | 90348 | A | RM 3.501.1-01A |
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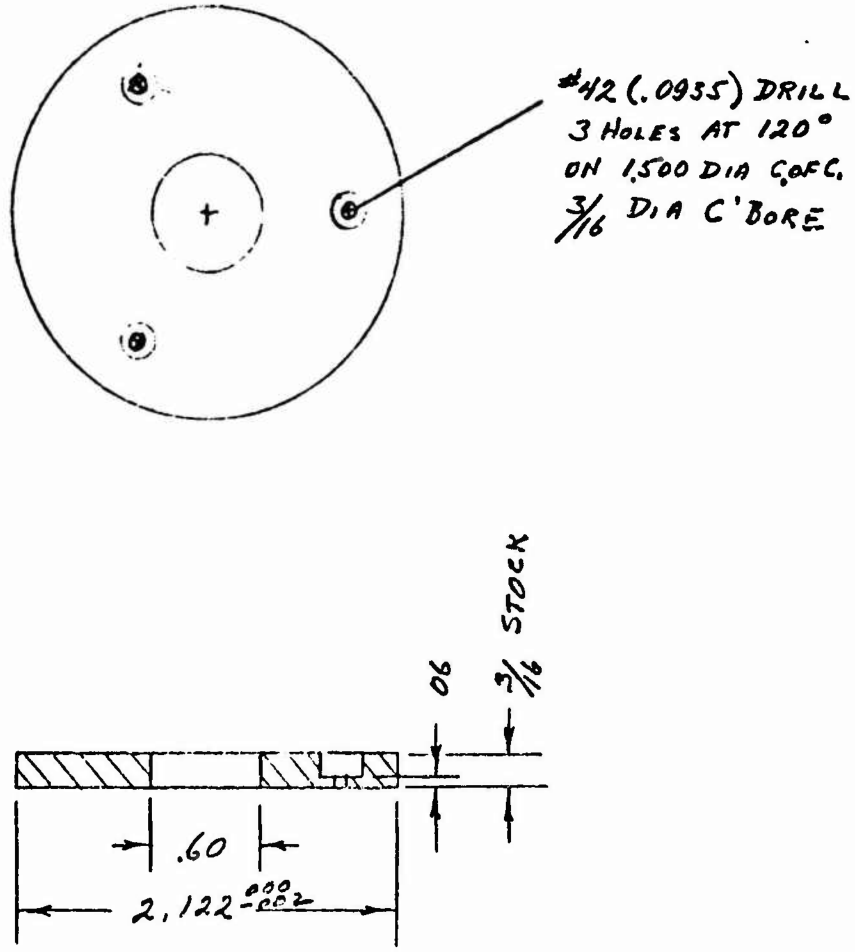


MATERIAL:- G7 FIBERGLASS (SILICON REENFORCED)

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

PAD, NOSE

USED ON

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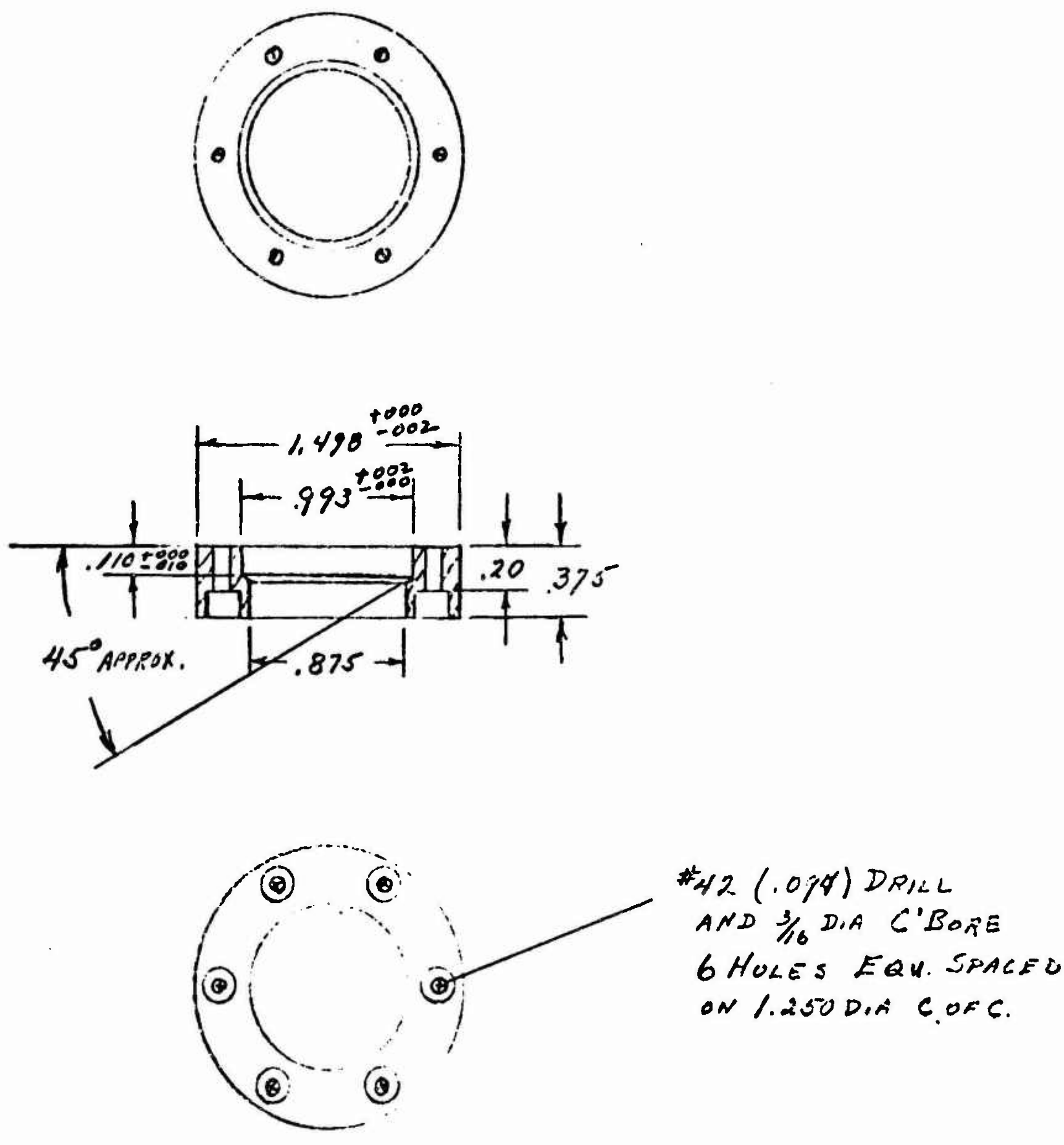


MATERIAL: BRASS

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS | COLLAR |
|---|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | | |

| USED ON | CODE IDENT. NO. | DWG. SIZE | |
|---|---|---|---|
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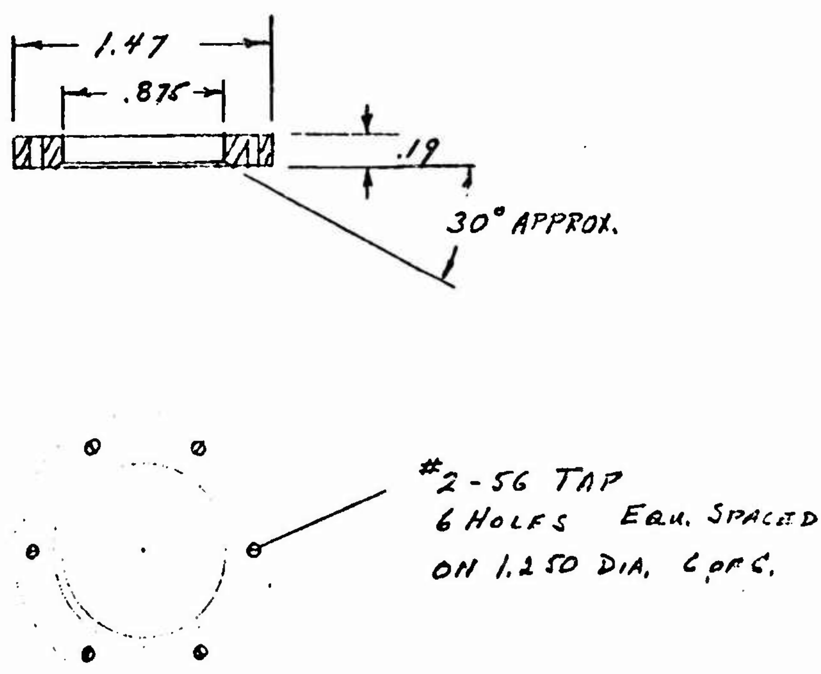


MATERIAL:- BRASS

| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

CLAMP RING

| USED ON | CODE IDENT. NO. | DWG. SIZE | |
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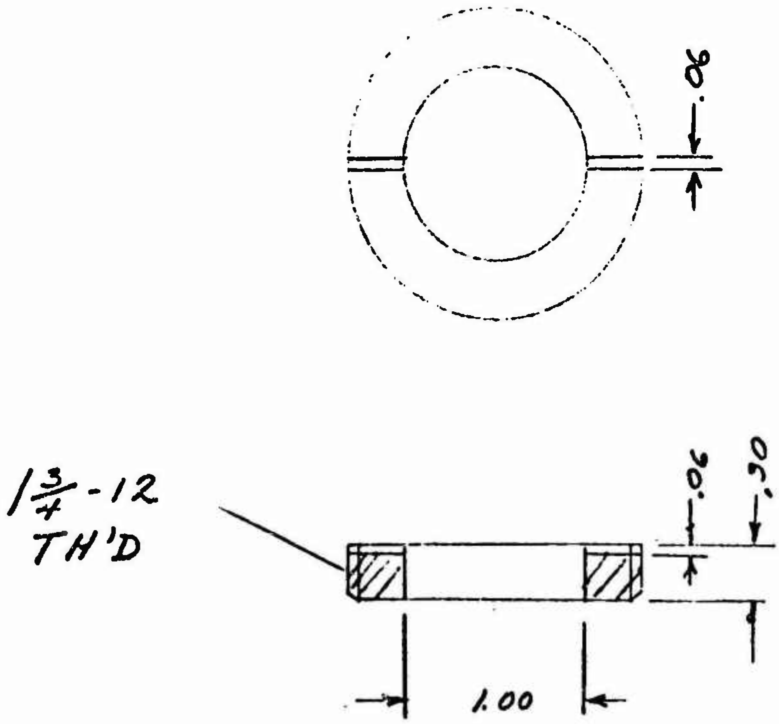


MATERIAL:- #303 STAINLESS STEEL.

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| TOLERANCES UNLESS OTHERWISE SPECIFIED | DIMENSION | UNDER 6 | 6 TO 24 | OVER 24 | FRACTIONS |
|---|---|---|---|---|---|
| | 2 PLACE DEC. | ± .02 | ± .03 | ± .06 | |
| | 3 PLACE DEC. | ± .005 | ± .010 | ± .015 | |

JAM NUT, LENS

USED ON

PREPARED BY [illegible] DATE 3-6-67

CHECKED BY DATE

CODE IDENT. NO. 90348

DWG. SIZE A

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3. REPORT TITLE

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Technical Task Final 29 Nov 1966 29 April 1967

5. AUTHOR(S) (Last name, first name, initial)

Vallese, Lucio M.
Wallace, Milner W.

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13. ABSTRACT

The work of design and fabrication of three Laser Telemeter Units having 18 channels of IRIG telemetry and using a PPM GaAs Laser is described. After a general discussion of the principles of telemetry and of the signal-to-noise enhancement properties of FM, PPM, and PCM systems, a detailed discussion of the electrical and of the mechanical design is presented. (U)

DD FORM 1 JAN 64 1473 11A 0101 807 6800

Unclassified
Security Classification

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Security Classification

| 14. KEY WORDS | LINK A ROLE | LINK A WT | LINK B ROLE | LINK B WT | LINK C ROLE | LINK C WT |
|---|---|---|---|---|---|---|
| Laser<br>Telemeter<br>GaAs Semiconductor Laser<br>PPM-FM Telemetry<br>Air-Gun Testing | | | | | | |

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